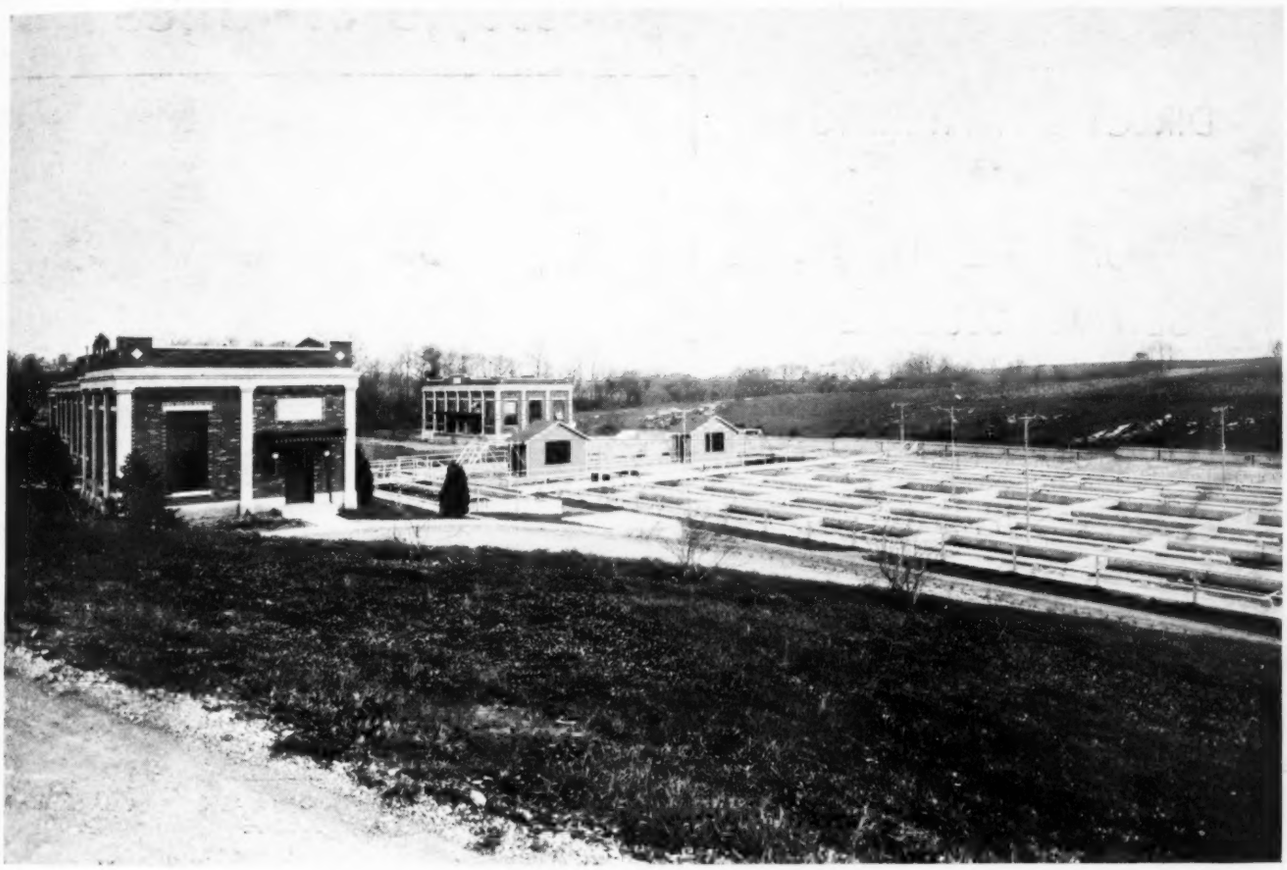
WATER WORKS AND SEWERAGE

, 1934 — Vol. LXXXI. No. 5



Sewage Treatment Works of Hagerstown, Md. (Fuller and McClintock, Engineers). On Left—Laboratory, Office, Blower and Pump House, Sludge Filter House in Center, rear beyond Clarifiers.

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Special Design for Separate Sludge Digestion

Equipment for Water and Sewage Laboratories

A Study of Filtering Materials for Rapid Sand Filters

Report of Meeting of Southeastern Section of A. W. W. A.

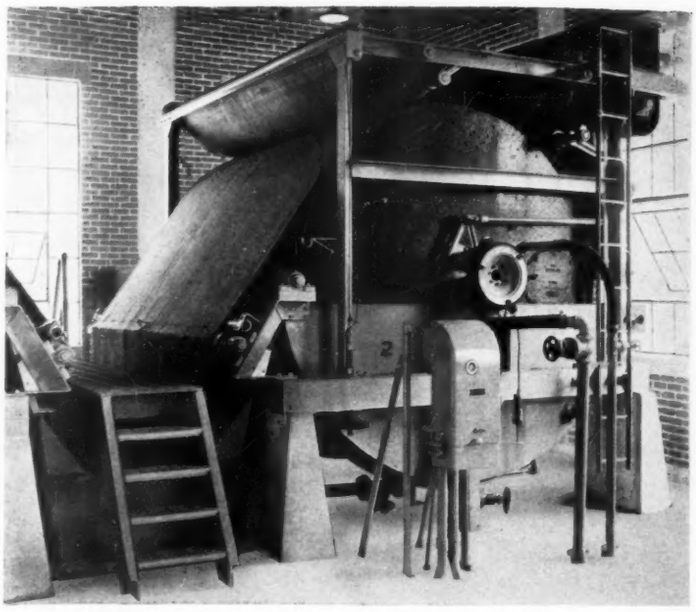
Dewatering Sewage Sludge by Vacuum Filters at Hagerstown, Md.

Eliminating Surge Troubles on Pump Discharge Lines of Washington Water Supply

Advanced

Method for dewatering combined undigested sewage sludges

DIRECT DEWATERING
of
UNDIGESTED
SEWAGE SLUDGES
by
VACUUM FILTERS
CAN SUPPLANT
DIGESTERS
and
SAND DRYING BEDS



VACUUM SLUDGE FILTERS AT HAGERSTOWN, MD.
Activated Sludge Treatment Works; Designed by Fuller & McClintock, Consulting Engineers

THIS PLANT IS THE FIRST TO PRODUCE A STABLE FILTER CAKE FROM ACTIVATED SLUDGE

SOME ADVANTAGES

- Installation Is Compact and Requires But a Fraction of the Area Occupied by Older Methods.
- Sludge Solids Collected in the Plant May Be Disposed of the Same Day—AND Independent of Weather Conditions.
- Operating Costs Are Practical When Compared with Older Methods.
- Installation Cost May Be Less Than for Digester Tanks and Drying Beds.
- Alkaline Sludge Cake Is Inodorous and May Be Safely Disposed of as Fertilizer on Land Without Nuisance.
- The Special String Discharge of the Filter Cake Minimizes Carbonation of Filter Cloths When Handling Limed Sludges.

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WATER WORKS & SEWERAGE

L. H. ENSLOW, Editor

LEADING ARTICLES To Appear in the Next and Subsequent Issues:

W. W. Brush, Chief Engineer, Department of Water Supply, New York City, will describe the work done by his Department in "Reconditioning Large Water Mains," which involves cleaning and application of protective coatings to old mains to restore their carrying capacities and extend their life.

E. E. Jacobson, Chief Engineer and Clark Cramer, Station Engineer, Lexington (Ky.) Water Company, in an article of unusual interest—"Water Works Kinks"—gives numerous practical operating "kinks" in purification, pumping and distribution practices which every water works man will be interested in and find useful. Martin E. Flentje, Chief Chemist of Community Water Service Company contributed several of the "kinks" included in the article.

N. T. Veatch, Jr., Consulting Engineer, Kansas City, Mo., will discuss values to be recovered from "The Utilization of Sewage" and the by-products of sewage treatment. The most recent development is the plant designed in Mr. Veatch's office for Herington, Kansas, the financing being based on income from the sale of effluent for industrial usage by a railroad.

Alexander Potter, Consulting Engineer, New York City reports the result of a study of the "Co-efficient of Friction of a Cast Iron Sewer After 30 Years Service" which gives a picture of the condition of the structure and its carrying capacity after that length of service.

Richard H. Ellis, Water Commission and Superintendent of Water Works, Newton, Mass., will describe what is believed to be the most modernized and efficient meter shop arrangement and meter repair and maintenance practice in the East. His article will be of particular interest to Superintendents.

Floyd A. Hoffman, Superintendent Water Works and Sewerage, Morristown, N. J., will describe an ingenious scheme of automatically controlling the sludge blanket level in final settling tanks at an activated sludge plant by use of the "electric eye" control of sludge return pumps.

Carl A. Heckmer, Department Engineer, Washington Suburban Sanitary District, Hyattsville, Md., and Chairman of the Plan Management Division of the A.W.W.A. will describe a successful and economical method of removing obsolete elevated water tanks.

Joseph Y. Reid, Superintendent Filtration, Trenton, N. J., will relate experiences with "Black Alum" during the past year in coagulating Delaware River water.

P. S. Wilson, Consultant in Water Works Practice, Glen Ridge, N. J., will continue his series of articles dealing with "Hydraulics"—which are designed for the practical Water Works operator. "Testing of Fire Hydrants" is a topic to be presented in an early issue.

John R. Baylis, will continue his discussion of "Filtering Materials for Rapid Filters"—Methods of testing and specifications will be suggested.

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Tyrone, Pa. original plant, producing Nuchar for many years, for purification of products required to meet the demands of the Pure Food and Drugs laws, U.S.P., etc. Mr. John W. Hassler in the upper left has been Superintendent since its inception. Lower left Mr. Henry Laughlin, water service man. Lower right, Dr. W. A. Welsh in charge of research.

Laying t

THE 1930-31 drought laid emphasis on the taste and odor bogey, which had disturbed the minds of water works operators for years.

What a difference in three short years. The bogey has definitely and finally been laid, and is absolutely under control. No water operator today need lose any sleep, worrying about bad tasting or odoriferous water. What is the answer?

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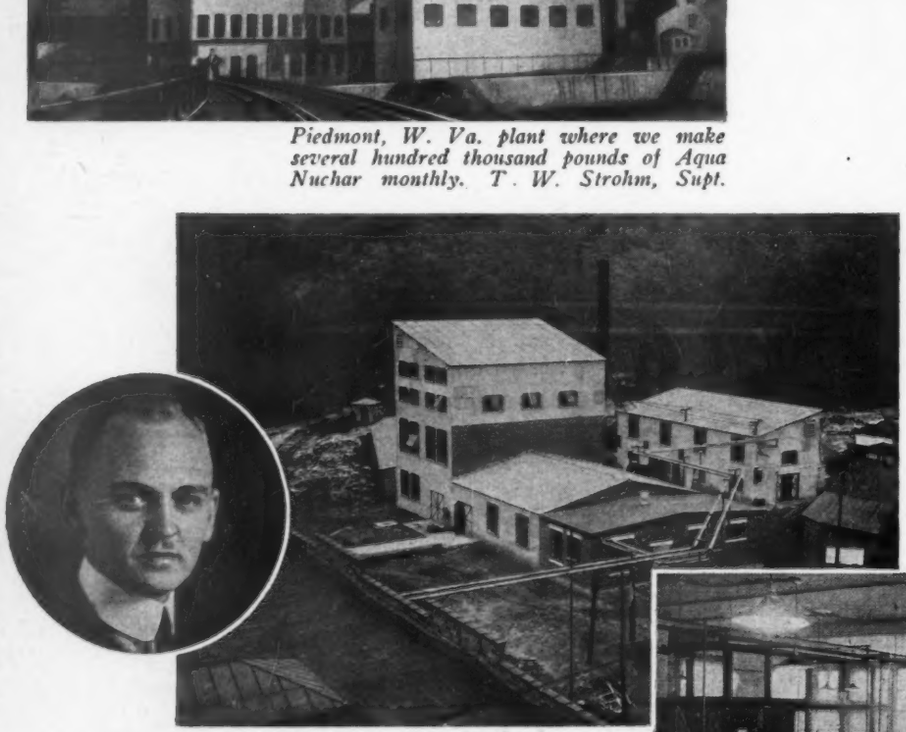
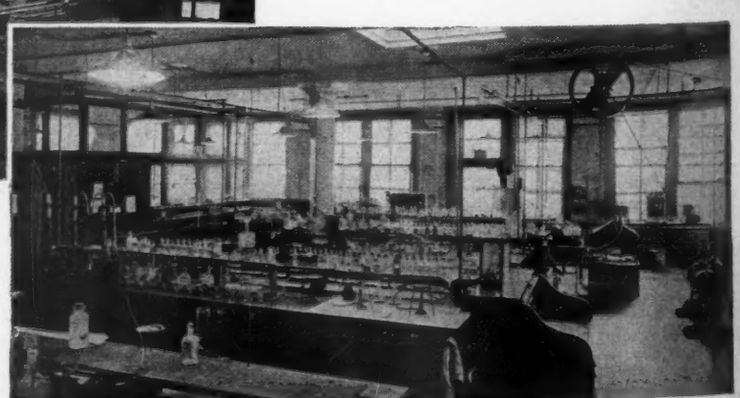


Covington, Va. new plant. D. S. Troubs, Supt.



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the Bogey

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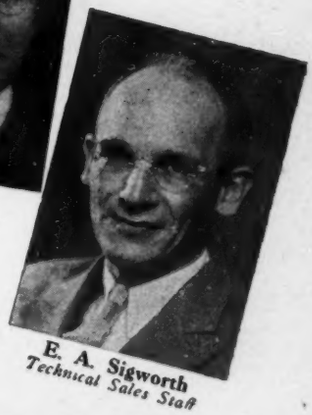

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The men pictured here will be glad to meet and greet you at the annual convention of the American Water Works Association in New York, June 4th to 8th inclusive. When you see a face that looks even remotely like the pictures, stop that man and make yourself known. Feel assured he wishes to meet you and help you enjoy the Convention and get the greatest benefit from your contacts there.

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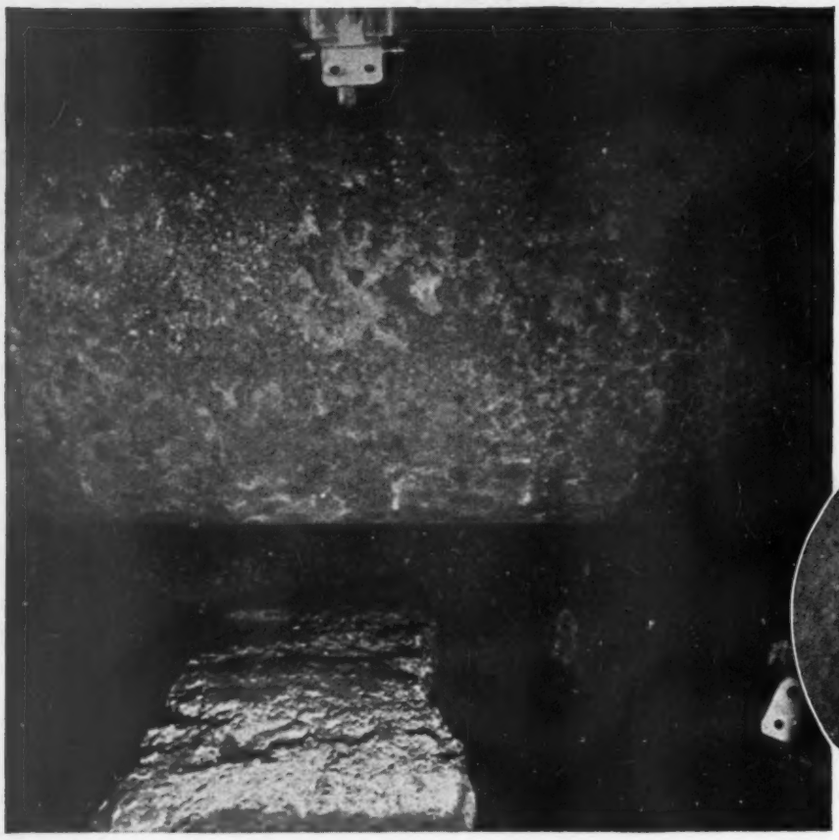

Below is shown a section of the world's oldest cast iron water main at Versailles, France, bearing the initials of the great "Sun King"—*Louis of France.* At left is shown section of main in underground gallery (object at top is part of photographer's lighting equipment).

THE oldest cast iron water mains in the world, by authenticated records, supply the town and the parks of Versailles, France. They were installed in 1664 by order of Louis XIV and are still functioning after 270 years of continuous service. The first photographs of these oldest existing cast iron mains in service underground were recently made for The Cast Iron Pipe Research Association, one of which is reproduced above without retouching. The insert photograph shows a section of the pipe in which is cast the initials of the "Sun King"—Louis of France.

Cast iron mains still in use after serving 100 to 200 years, and longer, have been recently uncovered and inspected in England, France, Germany and the United States. Taxpayers have saved and are saving enormous sums in taxes or rates by reason of the long life and low maintenance cost of cast iron underground mains.

The reason for the long life of cast iron pipe is its effective resistance to rust. Cast iron is the one ferrous metal for water and gas mains, and for sewer construction, that will not disintegrate from rust. This characteristic makes cast iron pipe the most practicable for underground mains since rust will not destroy it.

For further information, address The Cast Iron Pipe Research Association, Thomas F. Wolfe, Research Engineer, 309 Peoples Gas Building, Chicago, Illinois.

Methods of evaluating bids now in use by engineers rate the life of cast iron pipe at 100 years minimum

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Look for this TRADEMARK REG. *trade-mark*

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11 *years' service in Milwaukee, Indianapolis and Chicago Sewage Disposal Plants*

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More than five years ago "U. S." Rubber Engineers were called upon to develop an efficient, economical anti-corrodent.

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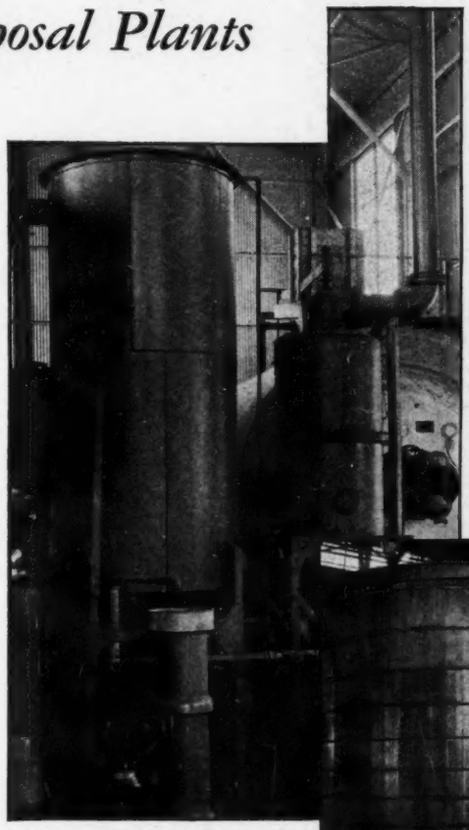
The Sewage Department of the City of Milwaukee was first to order Ferric Chloride storage tanks, piping and fittings, lined with this new "U. S." development. The city of Indianapolis followed suit one year later, and two years ago the Chicago Sewage Commission installed "U. S." Ferric Chloride Permobond at its Stickney plant.

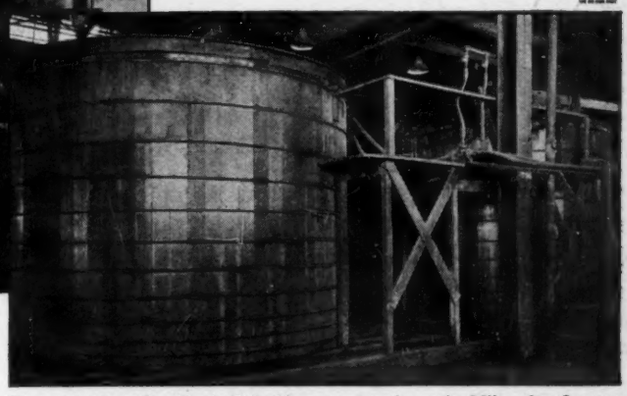
With this total of 11 years of service "U. S." Ferric Chloride Permobond has conclusively proven its superiority. *It has been subjected to longer service than any other rubber lining.*

"U. S." Ferric Chloride Permobond can be applied to wood or metal . . . tanks, pipe and fittings.

"U. S." Engineers will welcome the opportunity to cooperate with you in solving your Ferric Chloride problems. A phone call or letter will bring a representative without obligation.



Ferric Chloride tanks and piping at the Stickney plant of the Chicago Sanitary District are lined with U. S. Ferric Chloride Permobond.



These 12,000 gallon Ferric Chloride storage tanks at the Milwaukee Sewage Disposal Plant, measure 11 feet in diameter by 10 feet, 6 inches in height. Both are lined with "U. S." Ferric Chloride Permobond.

THE United States Rubber Company is the World's Largest Producer of mechanical rubber goods . . . makes the Most Complete Line . . . . maintains the Greatest Research Laboratories . . . and offers to industry a Technical Engineering Service of the Broadest Experience.

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Water Works & Sewerage, in the leading article for February, 1934, gives this record:

sludge and fresh additions

Ferric Chloride Treatment.—From August, 1932, to January, 1933, a small sewage treatment plant was operated by the Great Western Electro-Chemical Co. at Palo Alto, Cal., with the object of determining the effect of the use of ferric chloride in coagulation and the practicability of the Stevenson process of regenerating a spent coagulant through the use of chlorine In regard to the latter point, it was found that, as regeneration of the coagulant continued, a point finally was reached when the floc would not settle out. Furthermore, the chlorine demand of the spent coagulant increased with each successive regeneration. The regeneration feature has since been abandoned in favor of return of sludge and fresh additions of ferric chloride.

Regarding the use of ferric chloride, however, H. O. Banks has come to the conclusion that a suspended-solids removal of 85-90 per cent and a B.O.D reduction of 80-85 per cent can be attained, and that the cost of the process would be much less than for any other treatment process in use today which gives comparable results.

Great Western engineers have always adhered rigidly to the rule that the method of using a Bear Brand product should go hand in hand with the sale of the product itself. In the sanitation field, Great Western engineers produced the first electrolytic chlorine on the Pacific Coast; they introduced chloramine treatment of water supplies and sewage wastes on the Coast, using Bear Brand Chlorine and Ammonia; and they developed the ferric chloride treatment of water supplies and sewage wastes.

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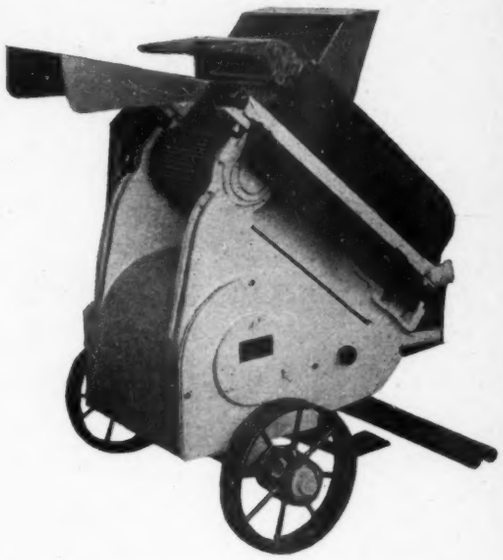

The ROYER SLUDGE DISINTEGRATOR will allow you to do just that. Many operators are finding a ready market for sludge for fertilizer. — Grand Rapids, Mich.,* and Dayton Ohio, sell their entire output—and, *at a profit*. Their major difficulty is in meeting the demand.

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*See July 1933 Issue WATER WORKS & SEWERAGE, for complete story.

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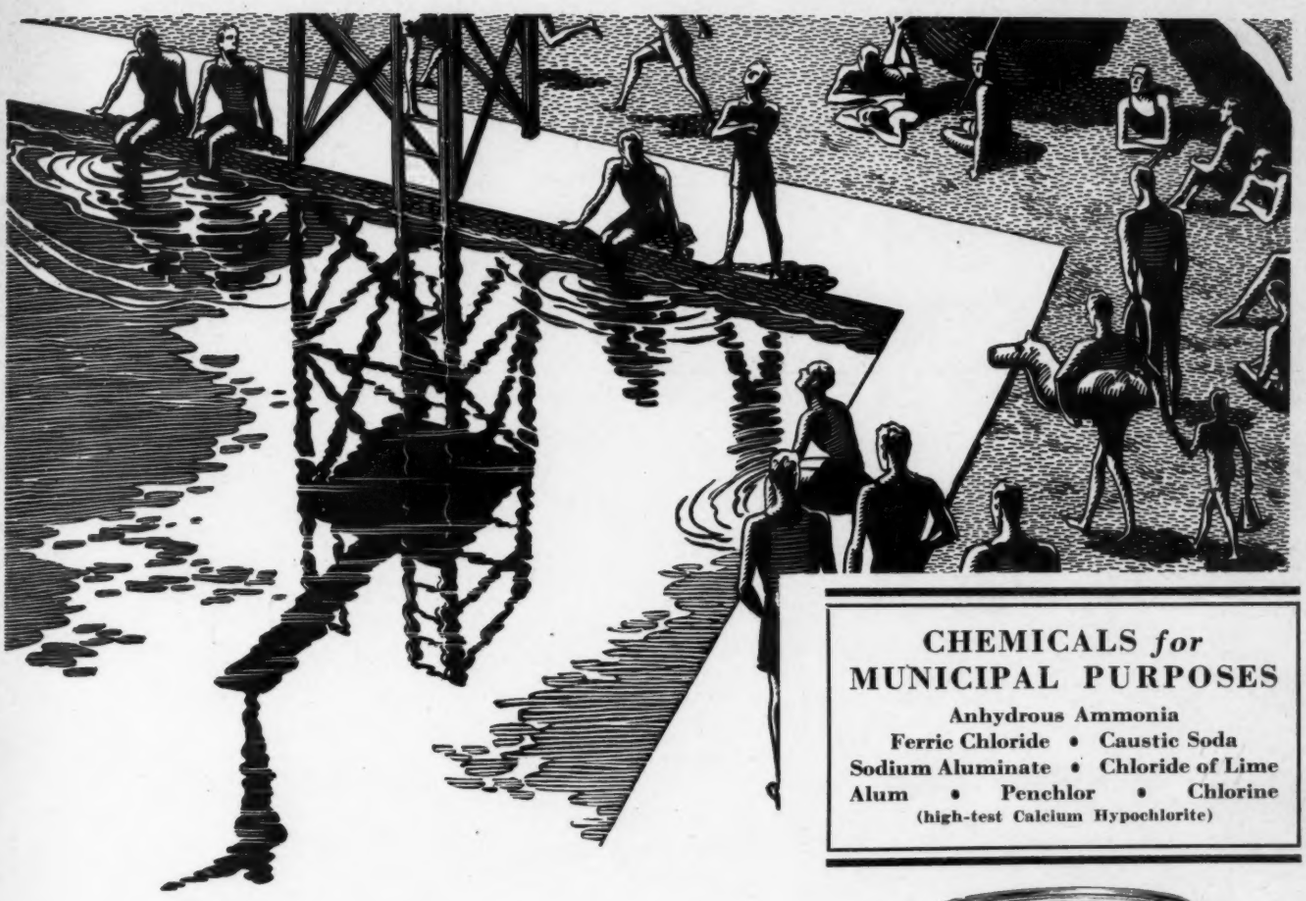

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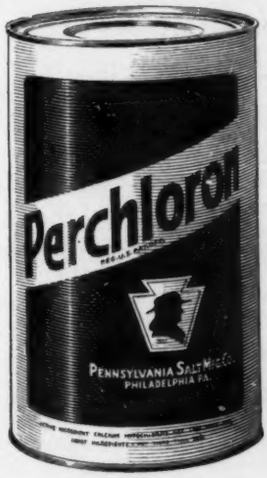

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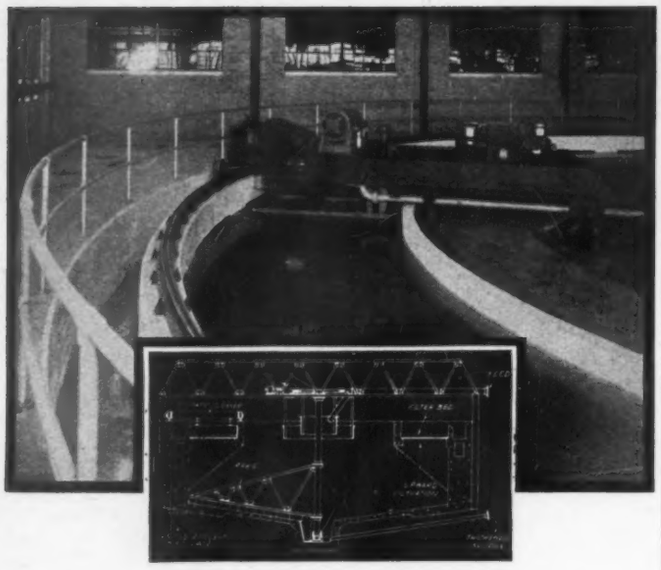

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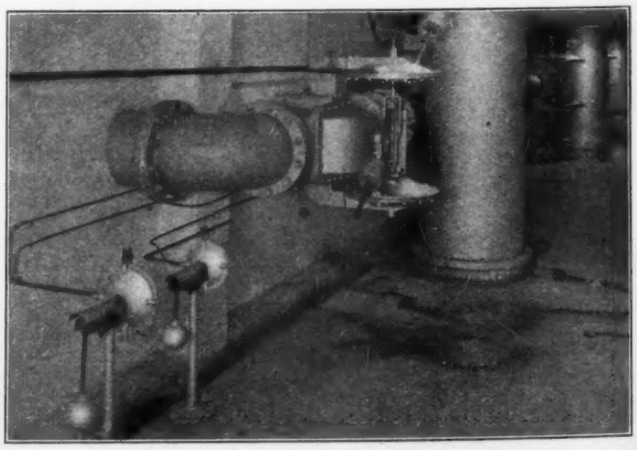

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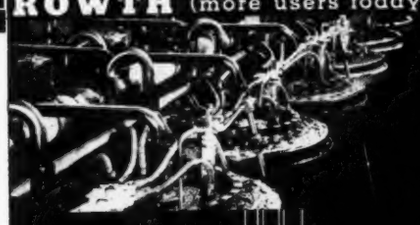

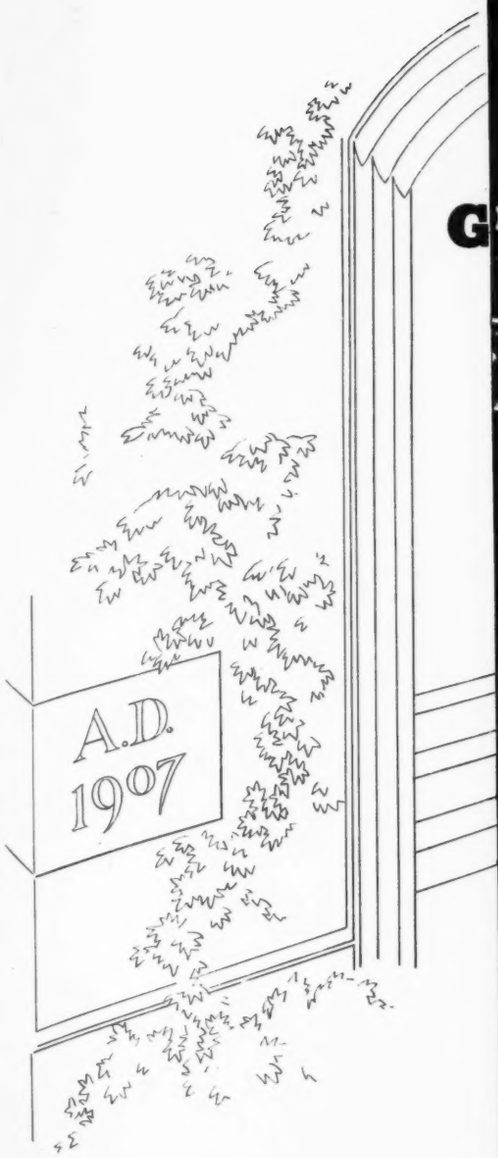

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Dear Fellow Member:

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You know from past experience that only at these Conventions do you have the opportunity to meet so many other members whose problems are your problems and whose satisfactory solutions might well be your satisfactory solutions if only you can get together with them and talk things over.

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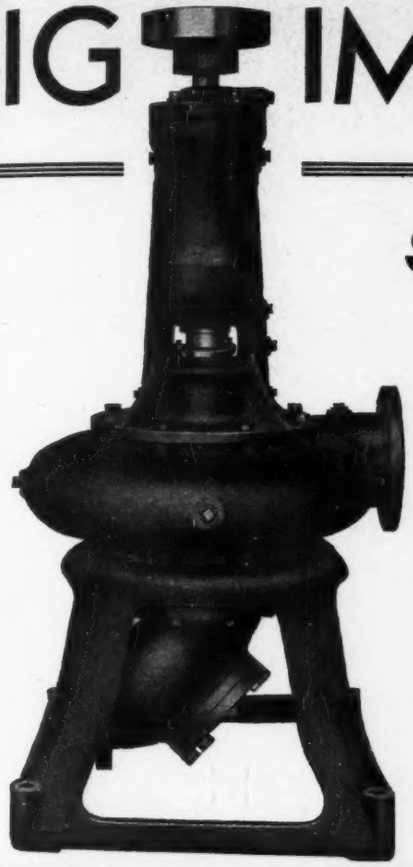

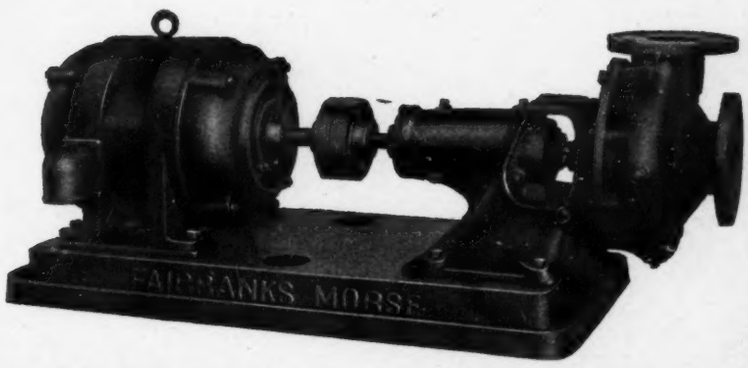

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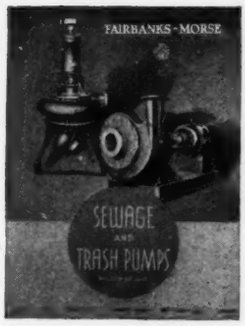

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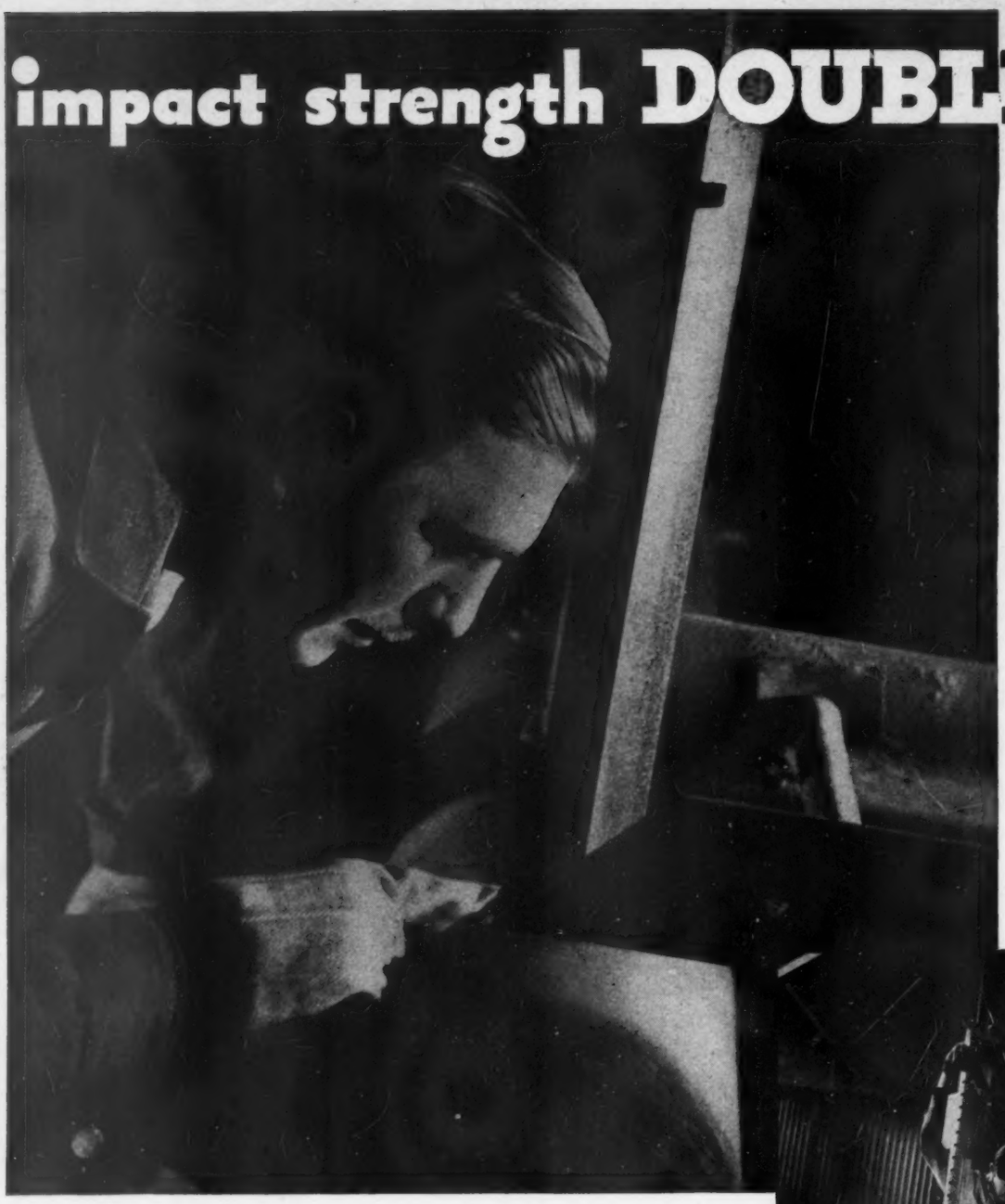

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WATER WORKS AND SEWERAGE
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DEWATERING SEWAGE SLUDGE BY VACUUM FILTERS AT HAGERSTOWN, MD.

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Chemical Engineer, Fuller and McClintock, Engineers, New York City.

The Author

ON May 2, 1933, a revamped and enlarged activated sludge plant for treating the sewage of Hagerstown, Md., was put into service. The treatment works,* designed for a future population of 40,000 and an average sewage flow of 4.0 m.g.d., have been described in another article. This article, therefore, deals only with the sludge dewatering and handling problems, which are believed to be of particular interest on account of the use of vacuum filters for dewatering undigested fine screenings, fresh solids and excess activated sludge.

Early Sludge Facilities

Hagerstown was one of the pioneers in this country with activated sludge treatment of sewage. The original plant, the major portion of which is incorporated in the modernized works, was constructed in 1924-25, employing a novel type of mechanical turbo aerator and means for dewatering the undigested sludges on open sand beds after heavy treatment with lime. During the eight years between the original installation and the modern installation of 1933, when the treatment was partly by activation and partly by plain sedimentation, the original sludge handling facilities were used with but moderate success. All sludge from the plant, including undrained fine screenings, was pumped to an octagonal concrete tank of some 1,300 cu. ft. capacity in the Service Building, which included facilities for storing and slaking lump lime. The lime dose, amounting to about one pound of good quality commercial quicklime per cubic foot of sludge was thoroughly mixed by means of a mechanical agitator and the mixture allowed to settle. The supernatant liquor was then drawn off by a swiveled decantation pipe and discharged to the raw sewage, while the thickened limed sludge was discharged by gravity to the 13 original open sludge beds comprising an area of 31,500 square feet. The sludge cake when sufficiently dry to be handled was removed as shown on Fig. 1, carted to the fields of the city-owned farm, some 300 acres in area, on which the disposal plant is located, and in due time was plowed in by the tenant farmer.

These arrangements for handling sludge were reasonably adequate during the early years, but developed shortcomings as the connected population and sewage quantity increased, particularly during the winter season. Due to the high lime causticity, the sludge drying was without offense and the pasty sludge cake, 2½ to 3 inches thick as removed, gave no trouble when spread on the fields, although frequently allowed to weather for a considerable period before being plowed under.

Experimental Filter Trials

The local elements entering into the decision to adopt vacuum filters for dewatering sludge, in preference to available alternates of extending the old liming method or installing digestion facilities, need not be discussed here. The principal obstacle to vacuum filters was the fact that mixtures of such raw sludges had not been dewatered in this specific manner. The use of vacuum

*See Front Cover Illustration.

filters for activated sludge was then a well-established practice but produced an acid cake which had either to be artificially dried to stable form for fertilizer use or else promptly buried. The possibilities of producing a stable alkaline filter cake at that time had not been explored, except in the case of solids precipitated by heavy lime doses applied to the sewage.

The Municipal Sanitary Service Corp. at this juncture believed that the difficult mixture of screenings, fresh solids and activated sludge could be filtered to a stable cake by the use of lime and paper pulp and offered to erect an experimental plant at Hagerstown to demonstrate the point. Such an experimental plant, comprising a 4 ft. 8 in. diam. by 4 ft. vacuum filter, with paper shredding equipment and other auxiliaries, was operated at Hagerstown in January and February of 1932. The results although not promising immunity from troubles incidental to developing a new process were deemed sufficiently gratifying to justify a plant scale installation, hence the idea was incorporated in design of the new Hagerstown plant.

Description of Sludge Filter House and Equipment

In the new plant provision was made to pump all sludges to the old lime conditioning tank (hereafter referred to as the Gauging Tank) in the Service Building, as had been the previous practice. The sludge collected in the pit of the Dorr fine screen, having 3/32 inch slots, is now separately pumped by non-clogging centrifugal pumps to the gauging tank, as before, and sludge from the preliminary settling tanks is delivered by other centrifugal pumps to the gauging tank. Excess activated sludge has during short periods been pumped direct from the underflow of the final clarifiers to the gauging tank, but experience has shown that on account of the high

Fig. 1.—Removing Cake of Lime Treated Sludge from Open Sludge Beds (Old Method)

water content of the sludge, averaging about 0.65 per cent dry solids only, it is not advantageous to handle the excess activated sludge in this manner. On the contrary it has been customary to "bleed" the activated sludge off the return sludge lines and thus discharge continuously at a low rate to the inlet end of the preliminary settling tanks. This method is simple from an operating standpoint; it results in a combined sludge containing about 3.0 per cent dry solids, but is not without serious disturbance at times to the aeration step because of failure of solids to settle satisfactorily in the preliminary tanks.

The sludge periodically accumulated in the gauging tank is carefully measured for volume, then sampled after thorough mixing with a mechanical agitator. The quantities of dry solids so determined form the basis for the record of dry solids taken out of the plant, rather than relying on the computed dry weight of filter cake. The reason for this will be obvious later. The mixed screenings and sludges, after measurement, are discharged by gravity to the new building which houses the conditioning and filtering equipment.

The sludge filter building itself is a substantial concrete and brick structure approximately 62 by 34 ft. in

Fig. 2.—Rear View of Sludge Filter House, Showing Truck Loaded with Filter Cake on Scale Platform (New Method)

plan, two stories high, as shown in Fig. 2. The basement floor contains space for truck parking and for receiving the filter cake, a concrete sludge storage tank, a concrete pulp storage tank, sludge and pulp pumps, filtrate pumps and heating equipment. On the main floor are the two vacuum filter units, vacuum pumps, paper shredder, paper storage and motors for the vertical shaft sludge and pulp pumps and tank stirrers.

The two vacuum filters are those manufactured by Filtration Engineers, Inc. They differ chiefly from other well known drum types of filter in omission of the compressed air cycle for loosening the filter cake and the substitution of a string take-off instead of scrapers. Filter drums are 8 ft. 6 in. in diameter by 10 ft. length and have a net filter area of 260 square feet each, or a total of 520 square feet in the installation.

The face of the filter drums is 12 mesh bronze wire for supporting the filter cloths. The filter cloth used is a light weight cotton muslin. It is held to the drum by wire wrappings at the end and by the endless cotton take-off strings spaced at intervals of about ½ inch.

The motorized equipment in the Filter Building is listed in the following table together with the nominal power demand:

	H. P. Motor-Drive
1—Paper Shredder, Jeffrey Mfg. Co., Type B3	20
2—Vacuum Pumps, Ingersoll-Rand, reciprocating, each	15
1—Sludge Pump Domestic 3-inch vertical centrifugal	2
1—Sludge Pump, Domestic 3-inch vertical centrifugal (modified)	5
2—Filtrate Pumps, LaBour, 1½-inch, each	3
2—Agitators for Sludge and Pulp Storage Tanks, each	3
2—Filter Drum Drives, each	1½
2—Sludge Mixers for $FeCl_3$ and Lime, each	¾
1—Dry Feeder for Lime, International	⅓

1—Stirrer for Iron Solution, "Lighting" Model D-1 ..... 1/3
1—Stirrer for Lime, "Lighting" Model T.... 1/6
1—Solution Feeder, Omega Precision..... 1/20

So much for the physical layout. Discussion of operation of the sludge filters will now be considered in two phases—before and after improvements were made.

Early Filter Operations

In the first phase of operations, wherein paper pulp was used as a filter aid, the sequence of operation is shown by the flow sheet, Fig. 3. The sludge accumulated in the gauging tank (A), averaging about 3.0 per cent dry solids, was dosed with quicklime in amounts

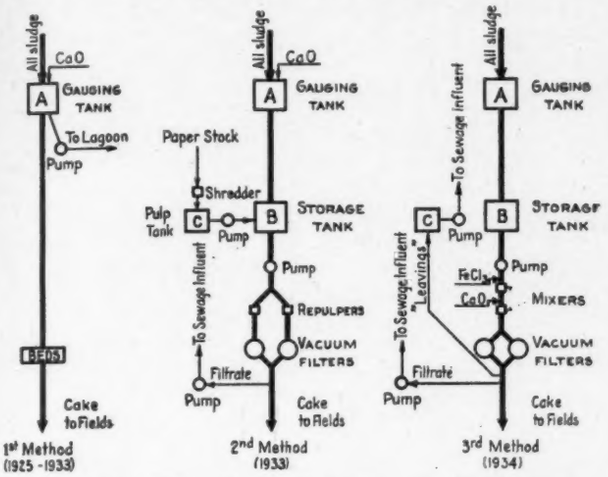


Fig. 3.—Sludge Flow Sheet, Picturing the Three Stages of Sludge Dewatering Developments at Hagerstown, Md.

sufficient to destroy odors of the sludge and to produce a cake which would later be stable and inoffensive on the fields. The average lime dose used was 17 pounds of commercial quicklime per hundred cubic feet of sludge, equivalent to about 9 lbs. of CaO in per hundred pounds of dry sewage solids. The sludge just prior to filtration had a pH of approximately 11. Smaller lime doses were apt to result in odor development in the sludge after exposure on the fields.

The sludge after liming was sometimes allowed to settle and the supernatant was drawn off and returned to the raw sewage, thus reducing the volume of sludge to be filtered. At other times the sludge could not be concentrated in this manner and the entire volume was sent to the filters, to the open sludge beds or else pumped to a lagoon. The sludge to be filtered was discharged by gravity from the gauging tank (A) to a sludge storage tank (B) of 2,000 cu. ft. capacity in the Filter Building. To this sludge was then added the desired volume of paper pulp suspension, the mixture was then well stirred and pumped to the vacuum filters.

The city of Hagerstown has no public collection of municipal rubbish and wastes, with the result that paper for the pulping operation must be purchased from various private sources. Almost every kind of waste paper has been used in pulping operation, newsprint, magazine, cartons and cardboard. Wheat straw has been substituted for paper stock on occasion, but with no advantage in economy or ease of handling. In preparation for the day's run of the filters sufficient waste paper was fed through the Jeffrey shredder into the pulp tank (C) of 1,050 cu. ft. capacity, partly filled by gravity with the activated effluent as solution water. By running the mechanical agitator in the pulp tank and recirculating the sludge with the pulp pump, the paper was reduced to the form of pulp containing about 3 per cent solids (by weight) of air-dry paper. The moisture content of the paper stock was quite variable and the bulky diversified material was not subject to accurate sampling. For that reason it has not been practicable to calculate the filter yields in terms of sewage solids from the cake taken off. However, each truck load of filter cake taken out of the building is weighed on the bulk scales, just outside the building as shown in Fig. 2, and composite samples are taken of the cake as it leaves the filter drum. It is measured for thickness and dry solids content is determined in the laboratory.

The above describes the set-up and operating methods employed during the first seven months of 1933. The results were disappointing in many respects. In the first place the yield by the filters averaged only about 65 per cent of the expected figure, decreasing materially with cold weather. Paper which at first was bought at $4.00 per ton increased in price to $8.00 per ton. The cake moisture was considerably in excess of expectations. The filtrate contained undue amounts of solids and was highly organic in nature due to prolonged contact of lime with the sludge prior to filtration. The "leavings" at the end of the filter run were also a source of annoyance. The residual sludge in the filter pans, together with the washings from hosing down the cloths, filters and floors constituting about 325 cu. ft. daily were collected in the sludge tank (B), and had either to be held for filtration the following day or to be pumped with additional lime to the sludge beds or lagoon. The paper shredding operation proved to be a formidable task involving extra labor and the entire filtering operation could not be consummated within an eight hour work day as expected. Rather than man the filter building for two shifts, the filters were called on for only such portion of the daily load of sewage solids as could be conveniently handled and the balance was sent to the sludge beds and lagoon as was formerly done.

Various attempts were made to assist filtration by conditioning the sludge with ferric chloride, ferric sulfate, ferrous sulfate, chlorinated lime and chlorine, added at

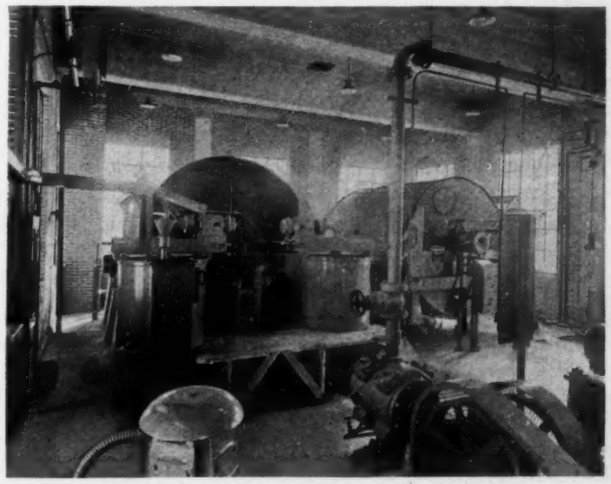


Fig. 4.—Interior of Sludge Filter Room Showing the Two Tandem Connected Sludge Mixer and Vacuum Filters. In the Foreground (Left) Is Motor Drive for Sludge Tank Stirrer, and (Right) One of the Vacuum Pumps

various points in the sludge system, but the large batch tanks and lack of facilities for continuous application of chemicals resulted in no appreciable gains over paper pulp alone.

Changes in Equipment and Methods of Filtration

In January, 1934, the Municipal Sanitary Service Corp., which installed the filter equipment, made a num-

ber of changes in the equipment and thereafter a different procedure was adopted for conditioning the sludge prior to filtration. The nature of these changes is best seen from the Flow Sheet, Fig. 3, which shows the three methods of sludge handling since the works were constructed.

The most signaficant changes relate to the following items:

1. Omission of lime to the mixed sludges in tank (A), this tank being now used only as a receiving and gauging tank, the contents of which are discharged by gravity into tank (B) in the Filter Building. Tank (B) is only used now as a storage tank for untreated sludge.

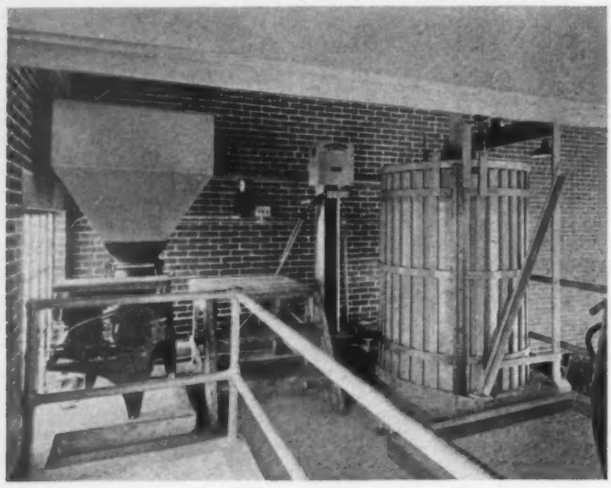


Fig. 5.—Chemical Feeding Equipment on Mezzanine Floor in Filter Building. Lime Feeder on Left; Iron Solution Tank on Right; Iron Solution Feeder in Center

2. Removal of individual mixers or "repulpers" from the filters and substitution of two mixers or flocculators operating in series to continuously mix, first, ferric chloride then lime with the sludge immediately prior to filtration.

3. Installation of equipment for continuous feeding of ferric iron solutions, and lime separately to the sludge as pumped through the mixers to the filters.

4. Regulation of sludge level in filter pans by an overflow ahead of the continuous chemical application to prevent chemically treated sludge from being recirculated through tank (B) by the sludge pump.

5. Discontinuance of paper pulp as a filter aid. The equipment for shredding and pulping paper is, however, retained.

6. Pump connections to permit discharge of "leavings" to the raw sewage at end of daily filter runs.

The present set-up is shown by the accompanying photographs. Fig. 4 shows the interior of the filter room, with the two new sludge mixers.

Mixers:

Both mixers are cylindrical steel tanks 3 ft. diam. by 4 ft. deep with dished bottoms and are thoroughly coated with rubber paint inside to protect from acid corrosion. They are practically identical except for the regulating overflow weir attached to No. 1 mixer (left), referred to in the 4th item of the listed changes. Each tank is equipped with vertical shaft wooden stirrers driven by ¾ hp. motor through reduction gears to give 21 r.p.m. travel to the stirring blades. The sludge pumped from tank (B) receives a dose of ferric chloride as it enters the bottom of No. 1 mixer tangentially, is mixed and flows out through a pipe connection near the top. It then receives a dose of lime, enters No. 2 mixer tangentially at the bottom, and flows out through a top pipe connection to either or both of the vacuum filters. Each mixer holds about 28 cu. ft. which for average conditions of filtering (2.0 lbs. dry solids/sq. ft./hr.) represents a retention mixing time of about 6 minutes for each chemical, with one filter unit in service and about 3 minutes retention with two filter units in service.

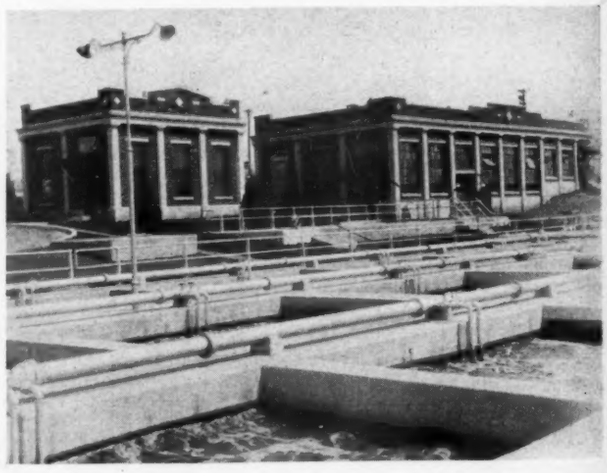
Chemical Feeding:

Figure 5 shows the equipment for chemical feeding as installed on a mezzanine floor in the storage room, at sufficient elevation above the main floor to feed chemicals by gravity. This equipment was chosen to allow the feeding of any iron salt, whether in powder, lump or solution form. A stoneware pot or tank, protected on the outside from mechanical injury by vertical wooden strips and iron bands, is 5 ft. deep inside and holds about 300 gallons. It is equipped with an out-board geared motor stirrer of double propeller type having a speed of 400 r.p.m. A solution of ferric salt of known strength is made up in the stoneware tank and fed by means of an Omega solution feeder, shown against the wall in the background of Fig. 5. This feeder simply lowers the hose outlet of the solution tank at a predetermined, adjustable rate. Rubber hose and stoneware pipe and fittings are used to conduct the ferric solution to the inlet of No. 1 mixer in the adjoining filter room.

For feeding lime an International dry feeder is provided and is suitable for any kind of pulverized lime, either quick or hydrated. The milk of lime is carried in an open copper gutter to the inlet of No. 2 mixer in the filter room.

Improved Operation by the Changes

The new equipment was put into service January 24, 1934, with immediate improvements in operating results. Since that date all of the solids of the plant, except coarse screenings and grease, amounting to approxi-



Hagerstown Sewage Treatment Works: Laboratory (Left); Screening, Blower and Pump House (Right); Grease Separation Tank (Center Rear of Aeration Units)

mately 4,000 dry lbs. per day, have been handled very comfortably by the vacuum filters on a single shift and without the use of paper pulp. The moisture of the filter cake (about 82 per cent) is still higher than had been expected, but is in line with filter operations elsewhere dealing with activated sludge. The cake thickness has increased from 1/10 inch to an average of about ¼ inch.

The continuous conditioning of sludge in two distinct stages has not proved to be at all tricky nor does it require skilled laboratory control. Frequent inspection of the sludge at the tops of the two chemical mixers is a

sufficient guide for adjustment of the chemicals. The sludge before treatment has a pH of 6. After mixing with ferric chloride it becomes well curdled at a reaction of pH 4.2. In the succeeding lime mixer the coagulation is more pronounced and the color changes to deep brown at pH 11.5. There are no odors connected with the filter operation except that of free ammonia. The sludge cake has no unpleasant odor, contains about 71 per cent volatile solids and, being highly alkaline, will be entirely free from offense when spread on the land, even if left to weather.

The cake is delivered by the filters into a steel bin with hand operated gates for discharging the cake into the bed of a motor truck on the basement floors. The loaded truck is weighed on bulk scales just outside the building as shown in Fig. 2 and the sludge is then hauled away and spread on the fields of the city-owned farm. On the average, nine loads are required daily to take care of the solids of the plant. There is no filtering or hauling of sludge on Sundays.

Operating Data

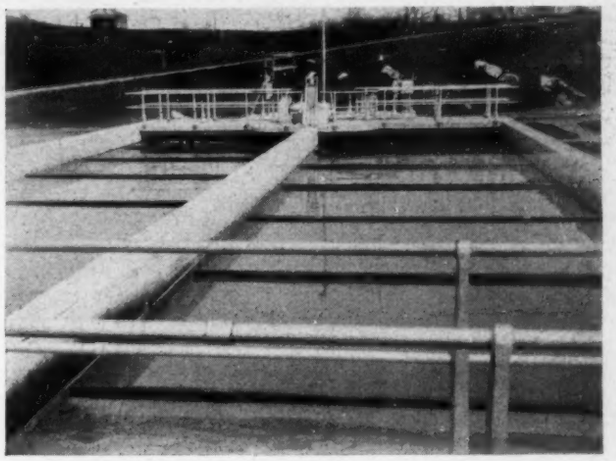
The pertinent data relating to the operation of the sludge filters during the two periods, before the filter changes were made and after the changes were made are summarized in Table I.

Costs

The cost of dewatering undigested sludge by vacuum filters is of particular interest in comparison with older and better known methods of sludge disposal. The sludge filter building with its appurtenances represents an investment of approximately $50,000. Of this total $16,000 represents the building, $29,000 the vacuum filters and auxiliary equipment, and the remaining $5,000 miscellaneous piping, sludge and pulp pumps, mixers, electrical work, etc.

The sludge filtering operations are carried out by a single operator on the day shift, for 6 days a week. A truck driver and helper remove the sludge cake from the Filter Building and distribute on the fields. The latter chore requires five to seven hours daily of the two men, the balance of their time being given to care of grounds, plant maintenance and miscellaneous tasks in connection with sewage treatment.

Electric power is from the municipally operated power plant. The sewage disposal plant is billed monthly according to meter readings at the same rates applying to commercial power users. The plant rate averages about 1.34 ct. per K.W.H. Power to the Filter Building is on 220 volt circuit, separately metered, but lights on the general plant circuit are not included. Water used in the Filter Building for washing the filter drums and for chemical solution feeding is not separately metered, but the monthly water bill is prorated at 15 ct. per 1,000 gallons.



Twin Primary Settlers, Hagerstown Sewage Treatment Works

The cotton filter cloths have a useful life of about 100 hours of operation before becoming so clogged that the yield decreases perceptibly. Removal of the cloth from the filter drum and soaking in dilute acid seems to promise longer usefulness. Replacement with new cloth, purchased and sewed locally, costs $4.00 each for material and $2.00 for labor.

In presenting below preliminary cost figures of sludge filtration, no consideration has been given to the 1933 operation when paper was used and when there was much experimentation and change of method. The figures given in Table II for February and March of 1934 are offered with some reservations as to their being repre-

TABLE I—COMPARISON OF SLUDGE FILTERING OPERATIONS FOR PERIOD JUNE 24, 1933 TO JANUARY 8, 1934, WHEN PAPER WAS USED WITH PERIOD FROM JANUARY 24, 1934, TO MARCH 31, 1934, WHEN NO PAPER WAS USED

	Before Changes	After Changes
Estimated connected population	28,000	28,000
Average sewage flow, m.g.d.	2.50	2.33
Sewage solids removed, dry lbs	892,265	220,685
Sewage solids to beds, dry lbs	374,083	3,705
Sewage solids filtered, dry lbs	518,182	216,980*
Per cent of sewage solids filtered	58	99
Volume of sludge filtered, cu. ft.	295,641	117,312
Sludge cake produced, wet lbs	3,043,737	1,171,455
Average per cent dry solids in cake	21.7	19.2
Dry filter cake, lbs	663,087	224,990
Thickness of cake, inches	.10	.23
Total filter hours (basis of 1 unit 260 sq. ft.)	3,098	425
Average net yield, lbs./sq. ft./hr	.65	1.97
Maximum daily yield, lbs./sq. ft./hr	1.50	3.10
Minimum daily yield, lbs./sq. ft./hr	.38	1.50
Paper used (air weight) lbs	246,480	0
Paper used, per cent of sewage solids filtered	47.5	0
Lime used (CaO basis) lbs	48,800	24,504
Lime used, per cent of sewage solids filtered (dry weights)	0	9.4
Ferric chloride used (anhydrous basis) lbs.	0	11,550
Ferric chloride used, per cent of sewage solids (dry weights)	0	5.5
Power used in filter building, K.W.H.	49,920	5,716
Power used per ton of dry solids, K.W.H.	166	53
Days filter was operated	168	58

*Includes 8,000 lbs. of solids conditioned with ferric sulfate instead of ferric chloride.

TABLE II—COST OF SLUDGE FILTERING AND DISPOSAL FEBRUARY AND MARCH, 1934

	Total Cost (2 months)	Cost Per Ton Dry Solids Filtered
Lime	$ 174.58	$ 1.81
Ferric Chloride	525.04	5.44
Labor for Filter Operation, hauling and spreading sludge	449.40	4.65
Power	73.46	.76
City Water	12.75	.13
Filter cloths and misc.	78.01	.81
Gasoline and Oil for truck	13.56	.14
Total	$1,329.45	$13.74
Sewage Solids filtered (dry lbs.)		192,957
Sewage Flow (mil. galls.)		137.4
Cost per million gals. of sewage treated		$9.70

sentative of future practice. It is better to consider them merely as useful indicators of trends in a new field.

Summarizing Discussion

It is evident from Table II that the principal element of cost is for chemicals used in conditioning the sludge, in this case $7.25 per ton of dry solids filtered. During greater part of the period covered, both lime and ferric chloride were purchased in less than carload lots. With the use stabilized to allow favorable contracts for chemicals, the chemical cost will be materially reduced.

The ferric chloride first used was in the crystallized (lump) form containing 60 per cent ($FeCl_3$). There was considerable trouble in weighing and dissolving the big chunks and there was some leakage from the wooden cask containers. Lately 42 per cent solution in glass carboys has been used but neither is its handling in small containers free from trouble.

Some trials made with ferric sulfate showed that comparable results may be obtained with this material but on the basis of iron (Fe) content more of the sulfate is required than chloride to do the same work. Prior to the filter changes, experiments had been made with ferrous sulfate oxidized with chlorine (chlorinated copperas), but were not successful in plant trials by the batch method, although laboratory tests indicated that the combination of chlorine with this cheaper iron salt might compete with ferric salts. Further plant trials with chlorinated-copperas by use of the new continuous feed equipment are contemplated.

The use of lime for sludge conditioning following the iron salt has several advantages. It improves flocculation to some extent and tends to give a firmer and drier cake. Lime prevents corrosion of the filter piping and structures and eliminates putrefactive odors, not only in the filter house but in the sludge after it is put on the fields.

Regarding the use of paper pulp as a filter aid, the Hagerstown experience was unfavorable on account of the fairly definite limit on yield with the particular sludge handled, the lack of consistent results day by day, the unsatisfactory quality of filtrate and the cost of paper. A ratio of 50 per cent of air dry paper to dry sewage solids appeared to be the minimum that could be dependably counted upon. Higher paper ratios gave better filterability but as the paper was added as a 3 per cent suspension (about equal to sludge solids), the volume to be filtered was increased proportionately. It is true that a sludge impossible to filter otherwise may be made filterable by the addition of sufficient paper pulp, diatomaceous earth or other porous filler. It is possible that in those communities where paper is collected by the municipality at a cost little above that of hauling paper to a municipal incinerator, paper pulp may be advantageously employed for sludge filtration.

The Hagerstown experience shows very clearly the advantage of a continuous method of conditioning sludge over intermittent batch methods. It can be shown quite readily by laboratory experiments with the Buchner funnel or test leaf-filter that the filterability of sewage sludge decreases quite markedly with increased lapse of time after the addition of coagulating chemicals. Similarly it may be shown that too much stirring of the sludge after addition of the coagulant is definitely detrimental to filtration. This is true also of sludge conditioned with paper pulp, without an iron salt. These facts have been thoroughly confirmed in the plant operations.

Acknowledgments

The writer who had general supervision of the initial operations of the Hagerstown plant is indebted to Mr. Samuel Greenawalt, City Engineer, and Mr. H. E. Rhodes, Superintendent of Sewage Disposal, for permission to use the operating figures shown above.

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Chicago Water Waste

Particular methods of achieving conspicuous waste of the people's money have a strange fascination for some public officials. Thus the wicked squandering of a large proportion of the water which, at heavy cost, Chicago pumps from the lake for public uses is preserved inviolate through the years.

The commission of distinguished engineers appointed to review plans of the Chicago sanitary district for spending $21,000,000 of federal funds allocated to its great construction program has viewed the city's water waste with shocked amazement. The recent survey of plumbing leaks on private premises conducted by the civil works administration reflects the commission's horror of the existing state of things. That survey disclosed 653,615 leaking faucets and bathroom fixtures in 359,148 homes and shops, indicating that there is a daily waste of city water amounting to 200,000,000 gallons. It is estimated that if all defective plumbing on private premises were repaired there would be an annual saving of $2,847,000 in the cost of pumping city water.

That estimate tells only part of the disgraceful story. In warm weather many faucets are left open day and night in order that the air in homes may be cooled and freshened by the running water. Leaking pipes below ground add much to the total losses. These and other forms of waste do not result from plumbing defects readily discernible in a general survey. The simple truth is, as experience amply proves, that on many unmetered premises, whether from deliberate abuses of the public water service or from undetected leakages, or both, more water is wasted than is used.

A small proportion of the defective fixtures disclosed by the recent survey has been repaired under the city's supervision, but now the work has stopped, organizations of master plumbers having made loud protests against repairs which deprive their members of profit. So the city goes on pumping floods of water which it knows will be wasted. Meanwhile the work of metering city homes proceeds at a laggard pace, after having been suspended for years. In the metered home water waste ceases because payment for it comes out of the householder's pocket. But the cost to him of metered water used freely for all desirable purposes ordinarily is less than what he would pay at frontage rates.

Any rational system of municipal housekeeping would have made Chicago a completely metered city long ago. That probably would have cut in half its present bill for pumping water. Metering would make unnecessary the future expenditure of millions in enlarging lake and land tunnels. It would reduce greatly the cost of the sanitary district's sewage disposal works. The report of the federal commission of engineers which has been investigating these and related matters has gone to Secretary Ickes. It would not be surprising if that report should take the city severely to task for its reckless course in fostering water waste on a gigantic scale.—Editorial in Chicago Daily News.

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A 1,200 Mile Pipe Line.—Construction is now under way on a pipe line for conveying oil from the Mosul oil fields in Northern Iraq to the terminal port of Haifa and Tripoli on the Mediterranean seaboard. The line will be 1,200 miles in length.

ELIMINATING SURGE TROUBLES ON PUMP DISCHARGE LINES OF WASHINGTON WATER SUPPLY

By D. M. RADCLIFFE

Engineer, U. S. Engineers' Office, Washington, D. C.

THE purpose of this article is to relate a practical means of preventing dangerous surges and water-hammer in water service pipe lines.

Almost all water works engineers are faced with surge troubles in main pump discharge lines or any long line, especially feeder mains without lateral branch lines. Usually the lines are of cast iron pipe, designed to withstand all surge conditions which might be encountered but in numerous cases the water-hammer, produced by surging, has blown pipe joints and in some cases has broken pipe lines.

There are several means of preventing surges in pipe lines, the best known of which is the surge tank. In most water supply systems it is not practical to provide surge tanks and therefore some other means must be employed if excessive surging is to be eliminated.

A common cause of dangerous water-hammer or surge in pipe lines of water supply systems is failure of the electric power input to motor driven pumping units. This sudden stop in pumping sets up a series of pressure waves or surges in the discharge pipe line. Much has been published with respect to water-hammer and its effects on pipe lines, therefore this article will discuss briefly a practical means of eliminating surge or water-hammer conditions. The method described has been in satisfactory operation on the Washington Aqueduct in the city of Washington, D. C., for the past eighteen months.

The Dalecarlia Pumping Station is equipped with nine synchronous motor driven centrifugal pumping units of 10 and 20 m.g.d. capacities. Three discharge pipe lines extend from the station to service reservoirs. One is a 48-inch pipe line, 12,350 feet in length with 110 feet working head; one a 36-inch line, 8,900 feet in length with 220 feet working head; one a 36-inch line, 15,950 feet in length with 340 feet working head. Three pumps are connected into each of these three lines.

Following accepted practice quick closing check valves had been installed in each of the pump discharge lines. Electric power failures, which occur several times each year, proved the cause of excessive and dangerous surges or water-hammer in the discharge lines. Records of the surges were taken on high-speed pressure charts and it was found that the maximum surge pressures recorded were 175 per cent above normal working pressure on each line.

Rotary Plug Type Check Valves Installed

After the pumping station had been in operation for approximately three years, it was decided to install check valves which would reduce to a minimum the loss of head through such valves. The new valves installed are of the rotary plug type and hydraulically operated. These are equipped with an adjustable timing feature to provide means of regulating the speed of closing upon pump shut-down or failure of electric power. Timing tests were made on the new valves to determine, if possible, a closing period which would limit pipe line surges to safe values. A number of closing periods, varying from one second to fifteen seconds, were tried. It was not permissible to employ closing periods in excess of fifteen seconds because a reverse flow of water through the pumps would take place and rotate the units backward at high speed. Since the pumps are not designed for reverse rotation this condition was considered unsafe and time of valve closing was limited to a maximum of fifteen seconds. In the series of closing period tests made, it was found that a five second period produced the best results, but the surge was still 100 per cent above normal working pressure. Unless the check valve can be left open until a surge is dissipated and then closed slowly, it is necessary to close the valve before the first supernormal return wave reaches the station or valve. In the case of the Dalecarlia Station, the first supernormal wave reached the station seven seconds after power failure. The results obtained by valve timing were therefore not considered satisfactory because these valves must protect pipe lines of concrete construction which were not designed to withstand the surge pressures encountered.

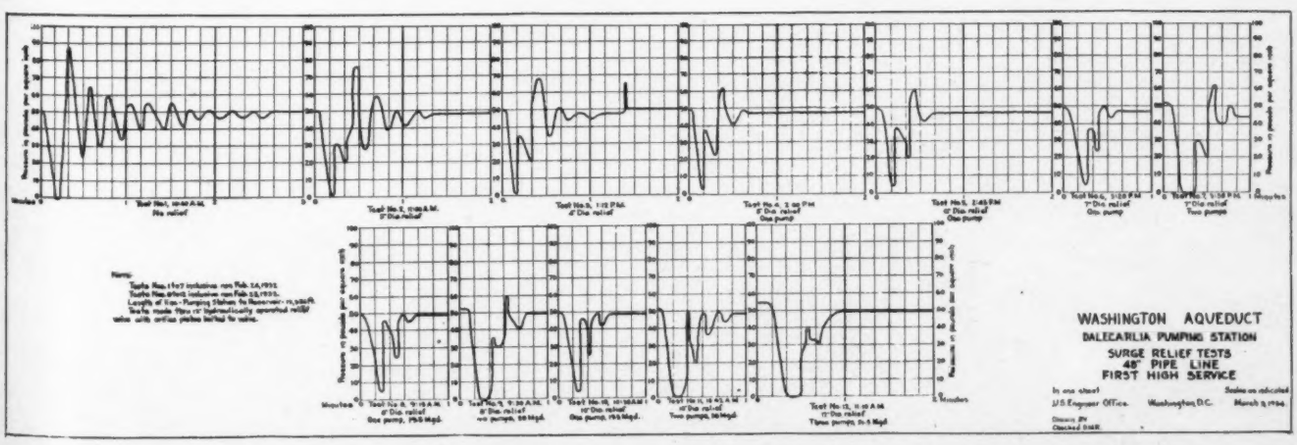

Fig. 1.—Results from Surge Relief Experiments, Employing Various Sizes of Relief Orifice

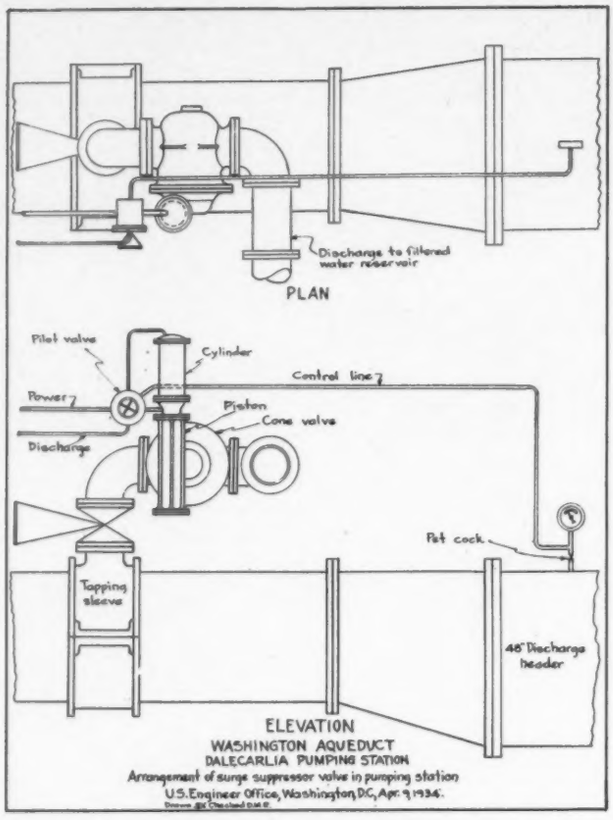

Fig. 2.—Sketch to Show Arrangement of Tapping Sleeve and Surge Relief Valves

Further Studies on Surge Relief

Investigations of different methods of surge suppression in pipe lines were then made. It was decided to provide a relief valve on each pipe header in the pumping station. To make the installation it was necessary to provide an outlet from each of the three pump-discharge lines. This was accomplished by installing "Smith" tapping sleeves (figure 2) with 10 inch outlets. A 10-inch gate valve was bolted to each sleeve to provide emergency shut-off. The discharge from each surge relief valve was carried into the filtered water reservoir to prevent waste of purified water.

Before deciding upon size of valves to be used, calculations and field tests were made to arrive at the size of relief required. The field tests consisted of a series of surge tests relieved through different sizes of openings. This was done by providing a 12 inch valved opening on one of the pumping station headers. A series of tests was then made under variable pumping conditions with the several orifice plates bolted on the valve. The valve was of the quick opening, hydraulic type, manually controlled. A signal system was installed to insure proper timing of test valve opening. The field tests included surge relief through openings 2, 4, 6, 8, 10 and 12 inches in diameter. It was found that the 2 and 4-inch openings had very little effect in damping the supernormal surge pressure. The 6-inch opening did not damp the first supernormal wave but did damp out the succeeding waves. The 8-inch opening entirely damped or eliminated all supernormal waves. From the results obtained in the field tests it was decided to install 10-inch surge relief valves on each of the pump discharge lines. The chart (figure 1) shows the results of the tests made with the orifice plates under variable pumping conditions.

Automatic Cone Relief Valves Installed

The surge suppressor or relief valves installed are of the hydraulically operated, rotary plug type (figure 2), manufactured by the Automatic Cone Valve Company, now a division of the Chapman Valve Company. Since the valves meet open when the pressure drops in the pipe lines it was necessary to supply water pressure for valve

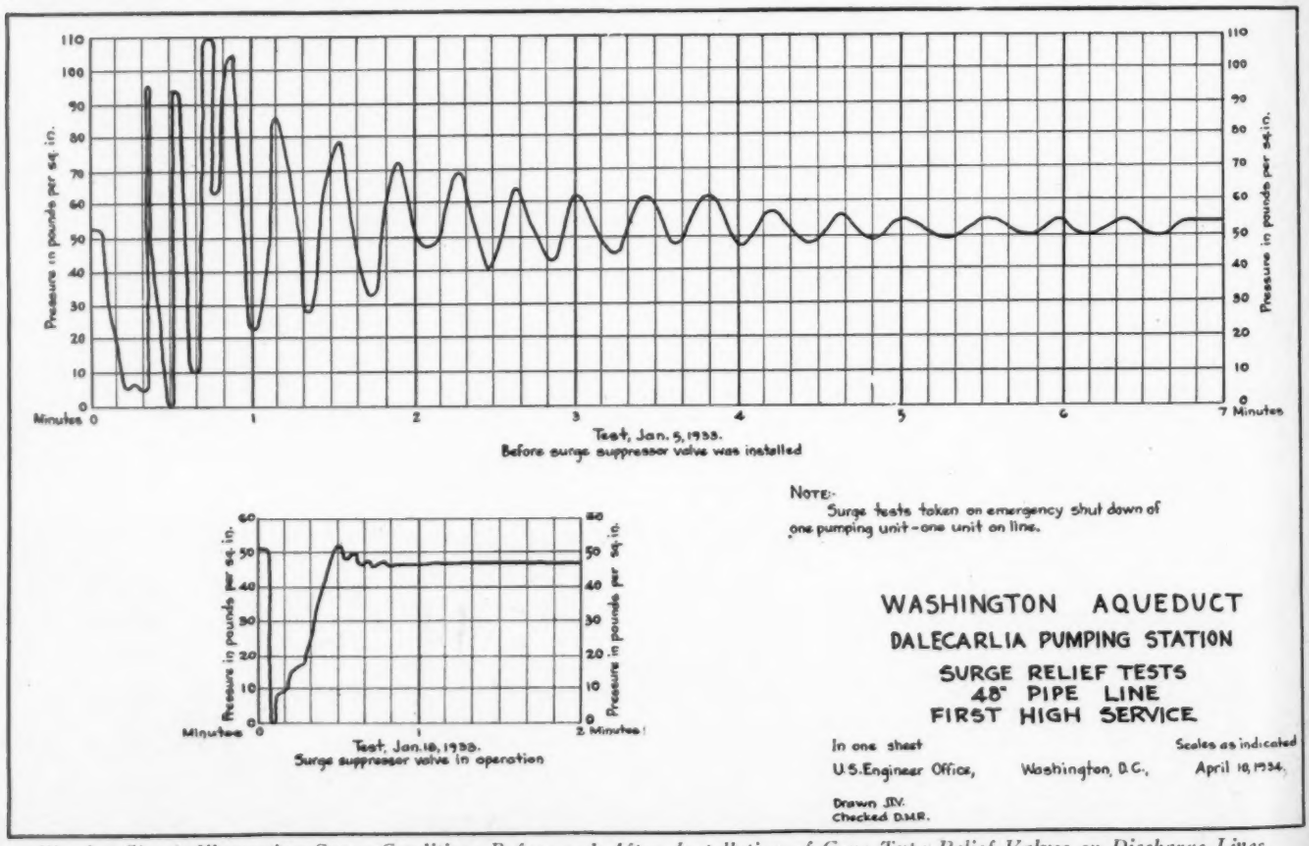
Pressure in pounds per sq. in.
Minutes
Test, Jan. 5, 1933.
Before surge suppressor valve was installed
Test, Jan. 10, 1933.
Surge suppressor valve in operation
NOTE:-
Surge tests taken on emergency shut down of one pumping unit - one unit on line.
WASHINGTON AQUEDUCT
DALECARLIA PUMPING STATION
SURGE RELIEF TESTS
48" PIPE LINE
FIRST HIGH SERVICE
In one sheet
Scales as indicated
U.S. Engineer Office, Washington, D.C., April 18, 1934.
Drawn JIV.
Checked D.M.R.

Fig. 3.—Charts Illustrating Surge Conditions Before and After Installation of Cone Type Relief Valves on Discharge Lines

operating from an independent source of supply. A 60-gallon residential supply water system was installed to insure an unfailing supply of water pressure to the three surge relief valves. The valves operate in the following manner; the normal pressure of the pipe line operates against a spring diaphragm pilot valve which admits control water pressure to the "closing" end of the hydraulic piston.

This holds the surge relief valve in the closed position. When a power failure occurs, the water in the pipe line flows away from the pumping station causing a sub-normal wave in the line. This results in low pressure against the control diaphragm, which allows a spring to operate the pilot valve, which in turn allows high pressure control water to flow to the "opening" end of the hydraulic piston which opens the main surge relief valve. The opening action is very rapid, the entire operation requiring only from 1.5 to 2 seconds. The average duration of the first sub-normal wave in the Washington lines is approximately 8 seconds, thus the surge relief valve is wide open before the first super-normal return wave reaches the station. With the surge relief valve open, all succeeding super-normal waves are dissipated through the open valve. The pipe line now assumes a penstock condition and the surge relief valve must be closed very slowly in order to prevent setting up penstock surges. This is done by limiting the flow of control water to the "closing" end of the hydraulic piston. For successful results it was found that a 2-second opening and 2.5-minute closing of the surge relief valves entirely eliminated water-hammer or surges in the respective pipe lines.

Results

The surge relief valves have been in operation in the Dalecarlia Pumping Station for a period of 18 months and during this time several power failures have occurred, and high speed pressure charts indicate that pipe line surges have been entirely eliminated as indicated by typical records pictured in figure 3.

Acknowledgment—This article is taken from a paper presented before the Maryland-Delaware Water and Sewage Works Association.

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Michigan Sewage Works Association Holds Tenth Conference

THE Tenth Annual Conference of the Michigan Sewage Works Association was held at Michigan State College, East Lansing, Michigan, March 26-30, 1934. The conference was preceded by a three-day short course in sewage analysis and plant hydraulics for operators. About 70 persons registered for the conference and 25 attended the short course, given by Professors Eldridge, Mallmann and Theroux of Michigan State College faculty.

Papers Presented

J. A. Volk described the Traverse City sewage treatment works which have now completed a full year's operation. A notable achievement has been the reduction of the pollution of Little Traverse Bay as indicated by the results of frequent bacteriological surveys.

James R. Rumsey, Supterintendent, Sewage Treatment Works, Grand Rapids, Mich., reported on experiences in operating small gas engines on sewage gas at Grand Rapids. He analyzed critically the performance of the engine. In general, it could be said that the engine gave very satisfactory service.

In a brief talk, Deputy Attorney General Gerald K. O'Brien discussed legal phases of sewage treatment. He stressed the manner in which legal decisions had followed economic conditions.

N. G. Damoose, Chemist, Sewage Treatment Works, Grand Rapids, Mich., outlined the effect of and results being obtained on the Grand River by the sewage treatment plant at Grand Rapids. A complete series of graphs showed the variation of D.O., B.O.D. and bacteria at several sampling stations above and below the treatment plant. A series of determinations made before the plant was constructed afforded comparative data indicative of the degree of improvement brought about by the plant.

Thomas Doyle, Superintendent, Sewage Treatment Works, Pontiac, Mich., related experiences at Pontiac from the plant operators viewpoint. Particularly significant was the comparison of the hit or miss methods used in operating the plant when he first took charge as compared to the scientific control of later years.

Dr. W. L. Mallmann, Michigan State College, discussed data obtained in chlorinating sewage at Flint and Traverse City. The addition of sodium thiosulphate to samples at the time of collection, he said, would give a more nearly correct picture of the effectiveness of chlorination.

George Hubbell, Hubbell, Hartgering & Roth, Engineers, Detroit, discussed the effect of inlet arrangements on sedimentation tanks. He presented an interesting comparison of various types of inlets on a model tank constructed in accordance with the old Dearborn Imhoff tank plans. As a result of the studies of the model a new type of inlet was developed and installed with a marked increase in sedimentation efficiency resulting.

An instructive illustrated talk on small activated sludge plants with mechanical aerators was given by J. E. Holst, Simplex Aerator Corp., Chicago. The adaptability of this type of installation was admirably shown.

Walter A. Sperry, Superintendent, Sewage Treatment Works, Aurora, Illinois, made one of his interesting talks on human relationship in connection with the routine plant operation. In addition, he discussed certain phases of plant operation and described quite fully the development of a sludge metering device, the use of which has been quite helpful at Aurora.

The conference went on record as favoring the adoption of rules and regulations for certification of plant operators by the Michigan Department of Health.

Officers elected were:

President—Pierre Welch, Supt., Sewage Treatment Works, Flint, Mich.

Vice-President—J. A. Volk, Supt., Sewage Treatment Works, Traverse City, Mich.

Secretary-Treasurer—W. F. Shephard, Asst. Engr., State Dept. Health, Lansing, Mich.

Director—E. C. Miller, Supt., Sewage Treatment Works, Dearborn, Mich.

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Merril S. Sabin, of Illinois Dept. Health, Dies

Merril S. Sabin, Principal Assistant Sanitary Engineer, Illinois State Department of Health, died at the age of 33, in Springfield, Ill., on April 21st, after an illness of three months. He is survived by his widow and parents.

Mr. Sabin was graduated by the University of Illinois in 1924 and had served the State Department of Health continuously for almost 10 years. He was instrumental in establishing the Water Treatment Plant Operators Association of Southern and Central Illinois. A native son of the State he served faithfully and well, his body was returned to his home in Antioch, Ill., for burial.

SPECIAL DESIGN FOR SEPARATE SLUDGE DIGESTION

By HENRY W. TAYLOR

Consulting Engineer, New York, N. Y.

Henry W. Taylor

THE usual plan for a separate sludge digestion sewage works is dictated largely by low trunk sewers and ground water conditions at the sewage works site. The sludge tanks are separated from the settling tanks in a double sense, as a matter of process and also as a matter of location. The usual layout involves sludge pockets at the inlet end of the settling tanks and the manual withdrawal of sludge from these pockets several times a day. There is also involved the pumping of sludge from a sludge well to the sludge digestion tank, which is at a location distant from the settling tanks to provide for the necessary embankment to protect the sludge tanks from low temperatures. Sludge tanks are generally located at an elevation above ground water for both structural and operating reasons and pumping of sludge is thus required. The withdrawal of sludge liquor from the digestion tanks is manually controlled or an intermittent overflow and the withdrawal is intermittent rather than continuous. A separate control of the digestion tanks is necessarily located in a building adjacent to the tanks which is at some distance from the settling tanks and the main office building of the sewage works. A considerable amount of inter-connecting piping is required between the sludge tanks, the settling tanks, the fresh sludge well, etc., consisting of sludge force drain, liquor drains, gas and water piping and overflows. The operator is required to divide his time between the settling tank location and the sludge tank location.

Where crude sewage is necessarily pumped from the trunk sewer to settling tanks which are at an elevation to eliminate back-water from the stream which affords ultimate disposal for the treated sewage, and occasionally, where a newly constructed trunk sewer can be maintained at a high elevation at the point of discharge to the sewage works, a simplified design may be utilized. This design eliminates some of the loss of motion in the usual layout and will tend to improve operating conditions and reduce the cost of the installaton. All of these three factors are equally important. The attempt to simplify a separate sludge digestion design for these particular cases has passed through several permutations and combinations and the accompanying illustrations together with the following description will serve to illustrate the form in which these various attempts have finally crystallized.

Special Design Features of the Settling Tanks

It will be noted that the settling tank extends over the digestion tank and the floor of the settling tank forms the roof of the digestion tank unit. The floor of the settling tank is sloped upward toward the inlet end where the settling tank depth is only 4.5 feet. The settling tank capacity is secured by an increased depth at the out-

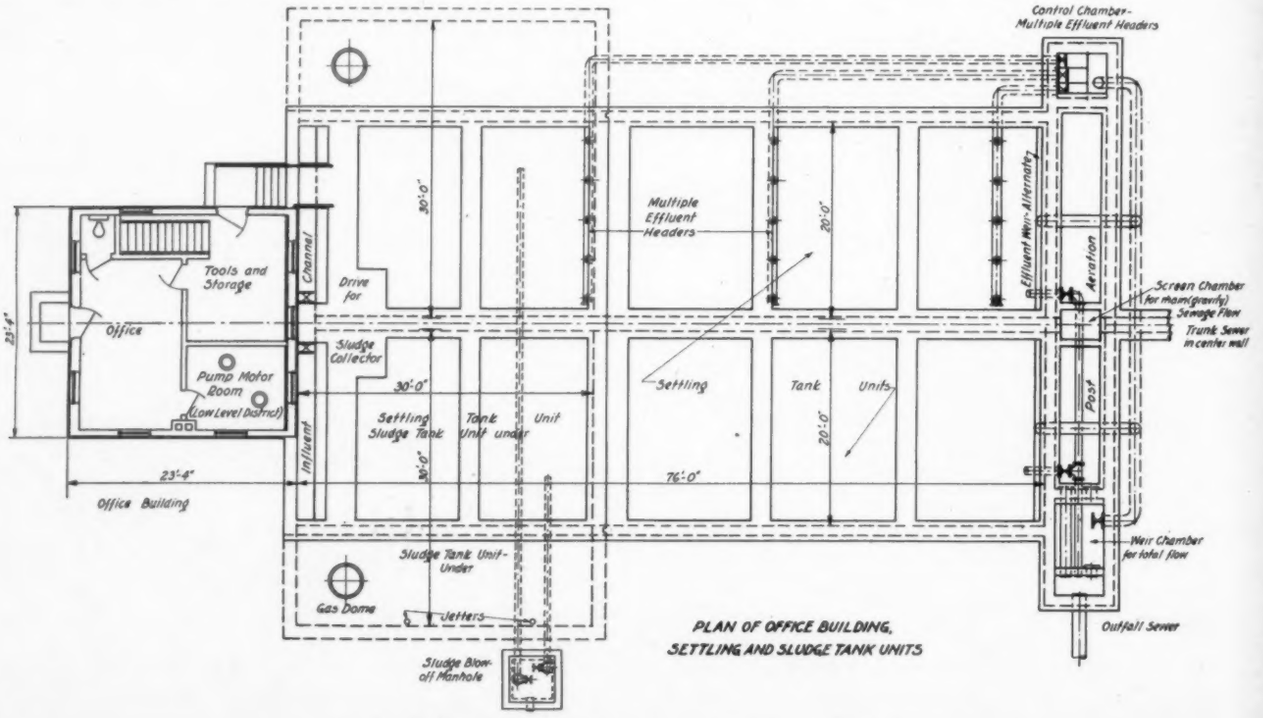


Fig. 1.—Settling Units and Sludge Tanks Shown in Plan.

let end which yields an average depth of about 6.75 feet. The sloping floor of the settling tank serves to decrease the depth of excavation of the sludge tank below. On the other hand, the increasing depth of the settling tank as the sewage approaches the effluent end of the tank, decreases the velocity of flow as required for efficient settlement of the finer sludges which settle, if at all, beyond the middle point of the tank. The provision of multiple effluent take-off headers, just beyond the third, the half and the seven-eighths points of the tank length is designed to further increase settling efficiency by the reduction of velocities as the sewage passes into the zone of increasing depth of the settling tank unit. The multiple effluent headers tends to supplement a horizontal travel of the sewage with a vertical flow induced by them. Withdrawing effluent as the sewage traverses the length of the tank also decreases the amount of remaining sewage required to complete the flow to the end of the tank. Two methods of reducing velocities are employed, first an increasing depth of cross-section, and second a decreasing quantity of flow—both being advantages to solids separation. It will be noted that the end effluent header is placed some distance from the end wall of the tank. It is readily admitted, even from the result of a casual physical examination, that there is a tendency for lighter sludge particles to rebound from the end wall of the settling tank and some of these finer particles are unnecessarily carried away in an end weir. The efficiency of the multiple effluent header has been demonstrated in the case of activated sludge sedimentation, at Chicago and elsewhere. How far this efficiency will be paralleled in the case of primary sedimentation is not known, but it would appear that a somewhat similar efficiency would result. It is thought that a carefully adjusted use of the multiple header will considerably increase the efficiency of a given tankage capacity, reduce the nominal period of detention and still improve the reduction of solids. The amount of effluent withdrawn from the first effluent header will probably be comparatively small in percentage and is estimated at 15 per cent. The withdrawal of effluent from the central effluent header is estimated at 35 per cent. If these estimates are within range of the actual, the last half of the tank would handle only 50 per cent of the total flow and the nominal capacity of the settling tank would be largely increased. For the end weir overflow, this tank unit has a capacity of 2.7 hours detention for the designed flow of about 700,000 G.P.D. When the multiple effluent headers are used for percentages of flow as stated, all the sewage is detained for 0.8 hour; 15 per cent is withdrawn, supposedly requiring no more settlement in as much as it will represent top liquor. The remaining sewage is detained for an additional 0.8 hour between the first and second headers, after which 35 per cent of the original sewage is withdrawn. The remaining 50 per cent of the sewage is then retained for another 2.42 hours. Some of the sewage is thus retained for about 4.5 hours. Should this same tank be operated at twice the normal rate, the maximum detention would be 2.0 hours and with three times the normal flow the maximum detention would be 1.35 hours. Theoretically, the solids are gradually settling downward and the top of the tank sewage should be free of settleable solids after 30 feet of flow, provided the draw-off is not so rapid as to induce upward flow of particles that are on the way down, but not very far as yet from the upper strata. The same applies to all header locations, with the additional factor that after 48 feet of horzintal sewage travel the settling solids are near enough the bottom strata to permit of a heavier draw-off.

Features of the Sludge Digestion Tank

The location of the sludge tank, underneath the influent end of the settling tank, renders it possible, with a sludge collector, to deliver the settled fresh sludge to an Imhoff slot which admits the falling sludge accumulation into the liquor stratum of the digestion tank. As this sludge has already settled through a sewage liquor, it will again, in an accumulated mass, settle down through a sludge liquor. The depth of the sloping baffle is 5 feet below the floor of the settling tank and the small deflecting baffle will be submerged in the sludge liquor within the digestion compartment, the floating sludge or scum being above this point and the bottom sludge being well below it. Jetter pipes are provided to keep the sloping baffles clean and jetter nozzles will provide means whereby the sludge accumulation can be leveled off throughout the length of the sludge digestion tank should such leveling be found necessary. It is thought that with the natural agitation produced by the gas bubbles passing through the digesting sludge and sludge liquor, the incoming sludge will normally adjust itself to a horizontal stratification. It will be noted that the top sludge and scum is subject to a 4 foot submergence and that it is never exposed to winter temperatures. The coldest exposure on the top sludge may be taken at about 40 or 35 degrees, whereas with sludge tanks installed in embankment the top sludge is more or less exposed to temperatures sometimes 40 degrees below zero in our northern climates. The sludge gas is collected at the side of the settling tank in a gas dome. In the area of the sludge digestion tank that extends beyond the settling tank, there will be installed two jets, controlled from above, which will discharge heated sludge liquor into the top sludge. This jetting will add heat and will provide agitation when needed. A hot water tank serving as a

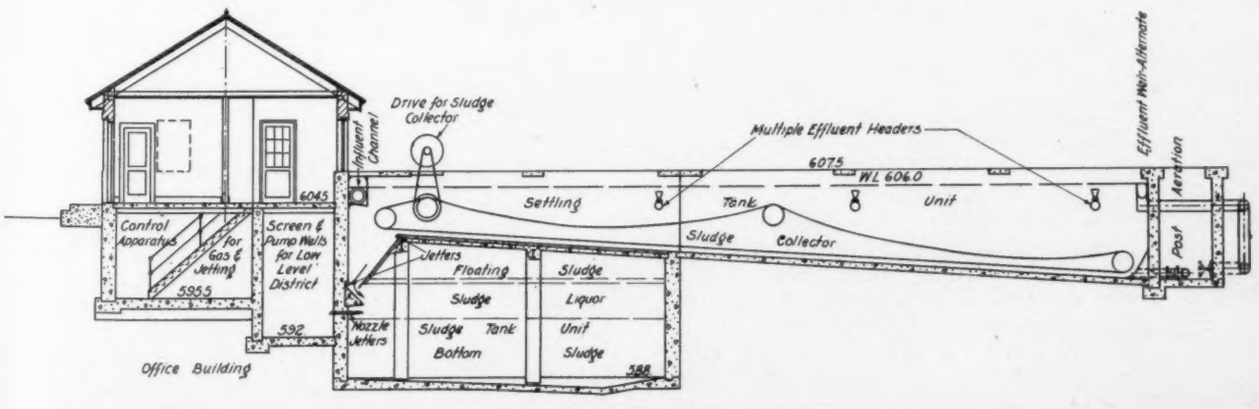
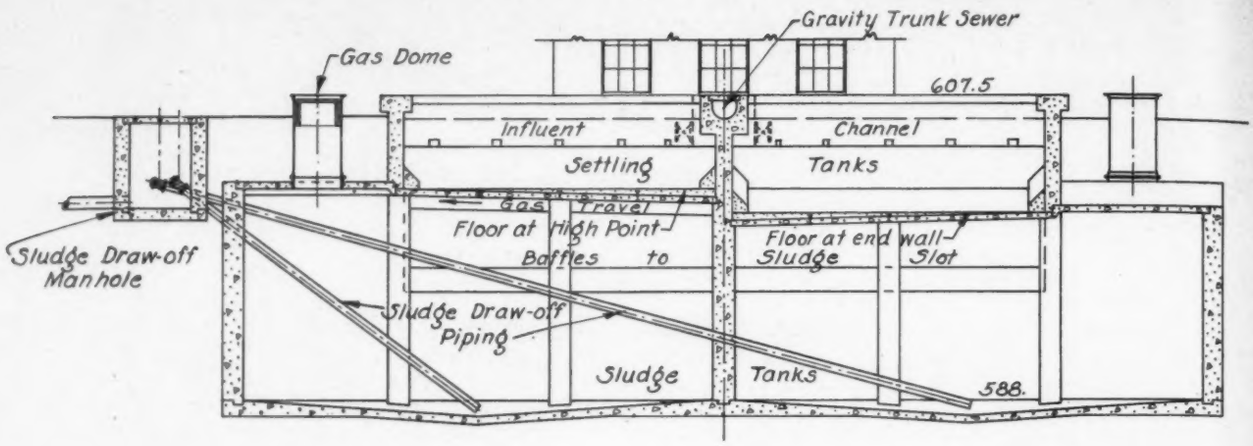


Fig. 2.—Settling Units and Digestion Tank—Longitudinal Section.



CROSS SECTION THRU SLUDGE AND SETTLING TANK UNITS

Fig. 3.—Settling Units and Digestion Tank—Cross Section.

super-heater for sludge liquor is provided in the basement of the office building so that the sludge liquor supplied to these nozzles can be raised from its normal temperature of 80 degrees to about 125 degrees.

Other Design Features and Advantages

The settling tank unit, the sludge tank unit and the main building of the sewage works are combined so as to have common walls and a complete control of all apparatus is centered in the basement of the office building. This centralization of the settling tank, the sludge tank and the office building make it unnecessary for the operator to walk from the settling tank to an isolated sludge tank location.

All control apparatus and equipment for all parts of the sewage works are centralized in one location and practically under one roof. The lost motion and the duplication of equipment and interconnections resulting from isolated location of separate units is eliminated thereby.

The time required to manually withdraw sludge from the usual sludge pockets, that required to pump the sludge and to keep the sludge pockets clear and clean is eliminated by the design and by the jetters.

The operation of withdrawing sludge liquor intermittently, is replaced by a more gradual and more continuous displacement of sludge liquor upwards through the slot after which it passes through the settling tanks, diluted with the fresh sewage. In this effect supernatant sludge liquor will be no more a problem in disposal than in the case with Imhoff tanks. The total volume and the rate of displacement of sludge liquors is a function of input of sludge solids.

Exposure to extreme cold weather is eliminated by the insulation provided by a layer of flowing sewage over the roof of the sludge tank.

All metering, recording and utilization of gas from the sludge tank is centralized in the office building and one heating unit can be used for heating both the sludge tank and the building. The time of the operator which is now spent in lost motion can be utilized in conducting tests and experimentation and the number of operators required for any given installation can be reduced.

This design as compared with a more nearly standard scheme, with the same capacities throughout, shows a 20 per cent reduction in concrete required and a considerable reduction in miscellaneous costs.

At least one unit of this type will be installed this summer and an opportunity will be thus provided to verify and amplify present knowledge and assumptions.

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Reducing Pumping Costs and Wastage

In a paper read before the Four States Section of the A. W. W. A., Frank M. Winder, Deputy Director of Public Works, Trenton, N. J., presented an illuminating story of how the Water Department of Trenton, N. J., had reduced pumping costs and water waste.

The consumption of water at Trenton has been brought down from 192 gals. per capita in 1913 to 100 gals. per capita in 1933. In the face of a population increase of 60 per cent during the 20 year period water pumped in 1933 was only 18 m.g.d. compared to the 21 m.g.d. pumpage of 1913. Mr. Winder explained that a Pitometer survey followed by major leak corrections had been the prime factor in reducing waste at a minimum of expense and effort. Thereafter followed a systematic house to house inspection for the purpose of checking the number of fixtures, locating and eliminating leaks. The work of this special crew had increased revenues by $17,000 per year at a cost of $6,000 per annum to maintain the crew. The leak inspection crews had paid their way handsomely.

The installation of meters had been of secondary consequence in raising revenues because of the very low domestic rates for metered water in Trenton (83 gals. for 1 cent) which had been due to the low power cost (¾ cts. per k.w.) for pumping.

Since 1915 the Trenton Water Department has been self supporting. In 1931 steam pumping bowed to the less expensive electric pumping at further savings. To improve distribution pressures and further reduce pumping costs two booster pumping stations have been installed at strategic points on the system. The wire to water efficiency of 81 per cent for the booster units constitutes a remarkable performance. Notwithstanding the low power rate the net savings have amounted to $2.00 on every million gallons of water pumped.

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FULLER & MCCLINTOCK MOVE TO NEW QUARTERS.—Fuller & McClintock, Consulting Engineers, New York City, who have been located for many years at 170 Broadway, announce the removal of their offices to 11 Park Place in order to procure increased facilities, greater space and a more central location.

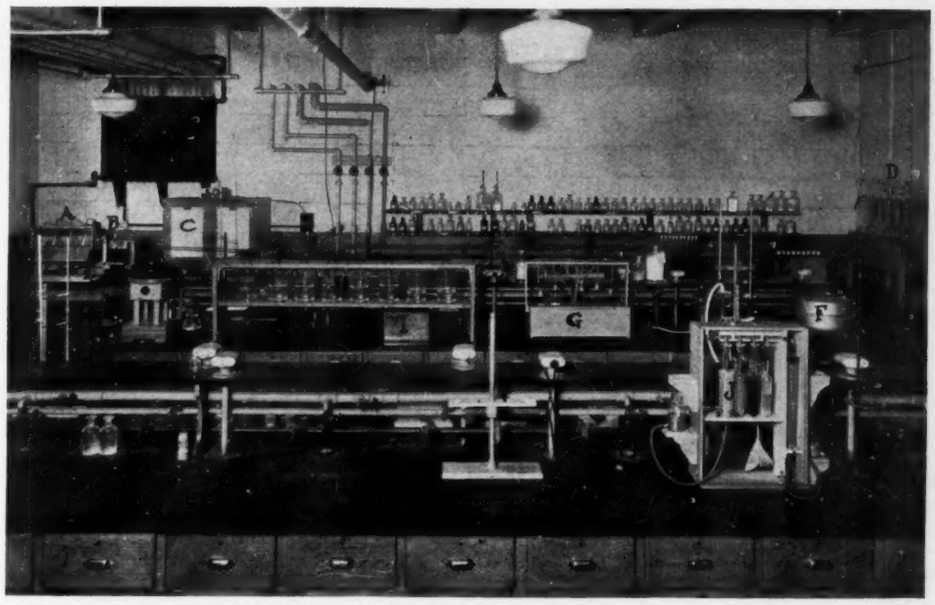
EQUIPMENT FOR WATER AND SEWAGE LABORATORIES

Apparatus Developed and Constructed in the Laboratory

By THOMAS M. RIDDICK*

New York University, New York

FOR more than twenty-five years there has been available to engineers and chemists a book of "Standard Methods" for use in making various tests required in the examination of water and sewage. However, if results are to be obtained from various plants which are truly comparable, there is some need for standardization of apparatus and technique employed in making these determinations. Sanitary laboratory equipment consists mainly of apparatus in general use by chemists, biologists and bacteriologists and the author has attempted to adapt this equipment more nearly to the needs of specific water or sewage analyses. When, however, appropriate apparatus was not commercially available from stock it has proved advantageous and economical to design and build the necessary items.



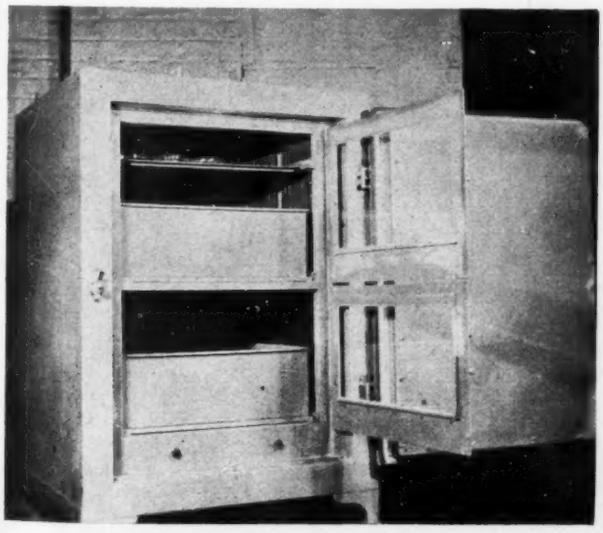
General View of the Sanitary Engineer Laboratory: (A) Steam Bath; (B) Calibrated Muffle Furnace; (C) Dry Heat Oven; (D) Kjeldahl Apparatus; (E) Colorimeter; (F) Centrifuge; (G) Ether Extractus; (H) Stirring Apparatus—(Flocculator); (I)Floc-a-lite; (J) Gas Analysis Apparatus.

Realizing the needs of smaller laboratories, the guiding factors in the design of equipment, to be described in this and future issues of WATER WORKS AND SEWERAGE, have been (a) facility of operation, (b) uniformity of results obtainable, (c) economy. It is hoped that these articles may prove of value to plants whose financial conditions require the building rather than the purchasing of laboratory equipment and will elicit discussion as to standardization of laboratory equipment.

The apparatus shown in the general view of the laboratory, has given efficient service for more than a year in the Department of Sanitary Engineering of which Professor Thorndike Saville is the head.

This article will be devoted to a description of only one piece of apparatus—the 20 degree incubator. Subsequent articles will describe other items of equipment shown.

*Instructor in Hydraulic and Sanitary Engineering.



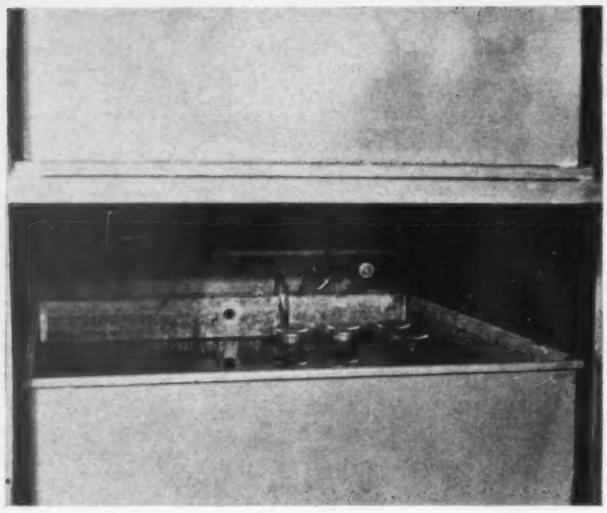
The Twenty Degree Incubator.

The 20 Degree Incubator

The technique, procedure and logic of the Bio-Chemical Oxygen Demand determination has been presented by Theriault and Phelps, in publications of the U. S. Public Health Service, namely, Bulletin 173, Supplement 90 and Reprint 1475 from Public Health Reports. Usually B.O.D. values are obtained by incubation at 20 deg. C. for a five day period, but without present knowledge of this subject it is comparatively easy to compute the 5 day 20 deg. oxygen demand from values obtained by incubation at temperatures other than this and for periods of incubation greater or less than five days.

In reviewing data from various plants and research organizations it is surprising to note the great variation in incubation procedure. In many instances, a room of "farly constant" temperature, or a tank located in this or that room has been used. Average temperature may have been struck from readings which vary as much as 5 degrees from the mean temperature.

Although a water seal for sample bottles has been



Close-Up of Water Tank in Incubator with Water Level Lowered to Show Inlet and Outlet Piping and Syphon for Emptying the Tanks.

recommended by Theriault and others, we have observed that in practice many laboratories incubate without this protective device. It is possible that results obtained under varying temperatures with or without the use of water seals may approximate values obtained under carefully controlled conditions, but such occurrences are more or less accidental. If no means of controlling the temperature is available, such results are perhaps better than none at all, but data of this type is valuable only in a relative sense to the plant at which it was collected. This procedure gives no surety of being able to duplicate results either at the laboratory in question, or elsewhere.

There are several 20 degree incubators on the market which are designed for or may be adapted to the B.O.D. determination. However, in many types the following disadvantages are noted:

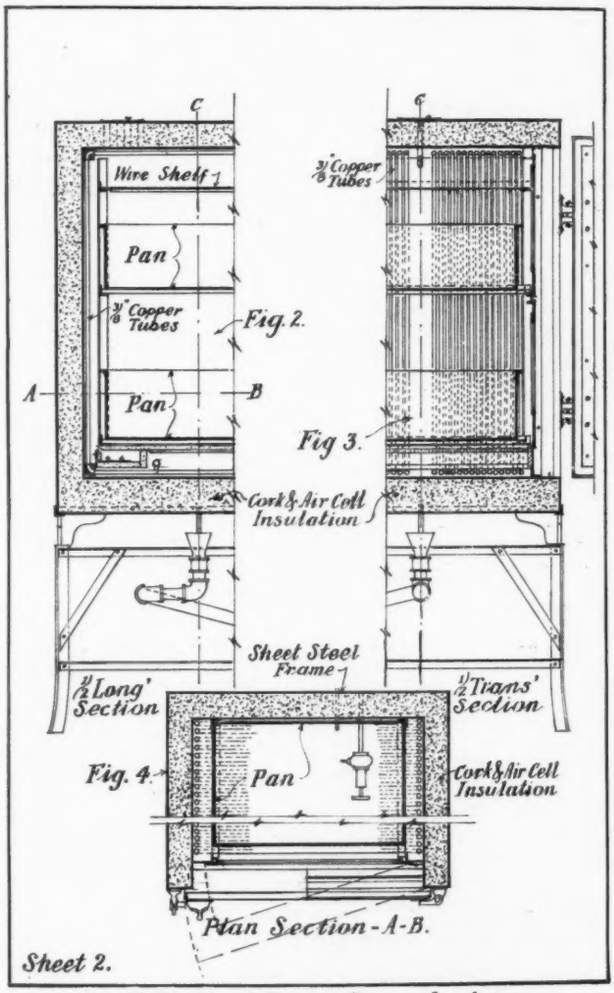
1. Lack of water tanks for providing water seals by submerged incubation.
2. High initial cost per unit capacity.
3. Too small capacities for continuous B.O.D. determination.
4. High operating cost due to refrigeration or icing, as well as the inconvenience of the latter.
5. Lack of facility for placing or extracting samples when water tanks are provided.

The incubator shown in the accompanying illustrations was formerly an electric refrigerator constructed of sheet metal, with the conventional asbestos air cell lining. The usual ice chamber or refrigeration unit has been omitted and an additional tank has been substituted. There are four coils or circuits of copper tubing extending around the bottom, top and sides of the incubator. A manifold, connected to the city water supply, supplies these coils with cooling water. It has been found that the tap water in New York City even during the hottest months of the year is always below 20 degrees C. and therefore by circulating tap water at a low rate of flow the cooling elements are always below this critical temperature. The use of a manifold to which is connected four separate cooling elements, instead of one continuous coil, insures a more uniform temperature in the incubator. The rate of circulation is controlled by a gate valve on the influent line, and from experience only a slight trickle of water is required for cooling.

Heating units are located within and on both sides of the incubator above the cooling coils and are shielded from the lower pan by a sheet of asbestos "transite" board. Circulation of air is provided by ports extending through the bottom of the incubator with corresponding openings in the top. The latter may be opened or closed by rotating a circular perforated cover plate.

A rod thermostat extends the entire width of the incubator and is located near the top to control the amount of heat supplied. Under working conditions the heating elements are automatically turned on and off about once every five minutes.

It is obvious that with this system of cooling, the upper or lower compartment formerly used for a refrigeration unit or ice box may now be utilized as space for an additional water pan. There are two pans or tanks each with a capacity of 36 standard (200-250 cc.) B.O.D. bottles. This allows the placing of 14 samples each day for continuous operation, or a total of 72 for each five days. Filling the tanks is easily accomplished by opening a valve directly above them, the water being drawn from the influent line. This procedure is quite an improvement on the old type of manual filling. Each tank is fitted with an overflow tube located at an elevation just above that of the bottle stoppers. When samples are placed in the tank a quantity of water equal to the bottle is displaced through this tube and goes to waste. This effectively prevents an overflow of the tank and insures a water seal of the bottles at all times. A siphon



Detail Sketch of Twenty Degree Incubator.

tube (pl. 3) is also soldered to the tank and extends down the side to the bottom for the purpose of drawing off the water if it becomes necessary to remove the tanks for cleaning. A wire shelf located above the upper tank provides space for fifty standard petri dishes if 20 degree bacteria plate counts are desired.

An important element in operation is that of a satisfactory circulation of air. This is controlled by the cover plates over the top vents. With little circulation there will be a saturation of moisture vapor in the incubator, and with the cooling coils always at a temperature lower than that of the air, there is danger of condensation of moisture vapor on the coils which will drip to the bottom of the incubator and cause rusting of the lining. The vents should be opened only enough to effectively prevent condensation. The effluent from the cooling coils flows to an open funnel which is connected to sewer, permitting a visual regulation of the amount of cooling water circulated. Rubber tubing connects both overflow tubes and siphons to the waste funnel.

This incubator has been successfully operated for over a year and has proved to be economical and efficient. The sensitivity of this apparatus is 1/10 degree with maximum variation in air temperature of plus or minus 1 deg. C.

Should the incubator be used in locations where cold water from the distribution system is above 20 degrees in the warmer months of the year, pre-cooling may be accomplished by passing the influent first through a section of coiled copper pipe built into any standard electrical refrigerator or refrigeration unit.

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Progress in Municipal Water Softening by Zeolites*

By A. S. BEHRMAN

Chemical Engineer,
International Filter Company, Chicago, Ill.

THERE are frequently advantages and economy in softening by zeolitic processes. Particularly is this true of small municipal installations or where non-carbonate hardness, requiring soda ash, has to be dealt with. In iron removal, zeolite is effective provided the iron is in solution and not partially oxidized before reaching the zeolite. Even a considerable coating of the grains with iron does not materially affect the softening capacity of zeolite. Not more than a 10 per cent lowering of capacity is observed and the same may be said concerning manganese removal.

In considering synthetic as against natural (green sand) zeolites, the increased speed of the synthetic product renders the cost of installation much lower because of permissible use of smaller softening units operated at higher rates. The capacity between regenerations is of the order of 9,000 to 12,000 grains of hardness per cu. ft. of synthetic as against 3,000 grains per cu. ft. of green-sand. The theoretical salt requirement in regeneration of the bed is 0.17 lb. per 1,000 grains of hardness removed. A fair figure for synthesized zeolite in practice is 0.35 lbs., however, as against 0.5 lbs. for the green sand. Under ideal conditions 0.19 lb. salt consumption is the lowest recorded in practice for synthetic zeolites. Wash water requirements will be 25 to 33 per cent of that needed in operations employing green-sand; and, a smaller number of regenerations are required because of the higher capacity of the synthetic product per cu. ft. Savings of 20 to 25 per cent in salt consumed and 50 to 75 per cent in wash water are worth considering when realizing that such savings may pay for the zeolite in 2 years' time, as exemplified in the case of Lancaster, O., and elsewhere.

In making zeolite installations one should consider the net cost—i.e., the balance between continuous expense (salt consumed) as against interest and depreciation on the initial investment in more plant capacity, more zeolite, to allow the use of slower rates with appreciable saving in salt. Another important consideration is the wear of the zeolite, but one should compute the replacement cost on the basis of gallons of water softened during the life of the zeolite rather than the less tangible "years of service." A high rate zeolite regenerated twice daily will pass 14 times the water that a slower zeolite with one washing per day will pass in a given period of service. For waters of low hardness, green sand will, in general, prove more satisfactory, whereas, for high hardness removal synthetic zeolites are preferable, other things being equal. The perfection of automatic regeneration of zeolite units represents a decided step in advance—particularly for small installations.

The effective size of the synthetic zeolite ("Crystallite") is 0.4 to 0.45, with a uniformity coefficient of 1.6 to 1.9. The loss of head at 3 gal./sq./ft./min. rates starts at 2 lbs. and increases to 6 lbs. after 8 hours of service; and, at a 5 gal. rate the head loss rate will double. The lower the hardness and the slower the softening rate, the higher will be the efficiency attained in salt consumption.

ROBERT SPURR WESTON, Consulting Engineer, Boston, Mass., in discussion, told of an experience in which 35 p.p.m. of free CO_2 in a well water had caused damage to the zeolite and lowering of its efficiency until addition of 15 p.p.m. of sodium silicate and sufficient soda ash to raise the pH value of the raw water to 7.2 had corrected the trouble. Salt consumption had been less than 0.4 lb. for each 1,000 grains of hardness removed. Zeolite softened water presented a corrosion problem which a readjustment to 35 p.p.m. hardness, by additions of raw water, had not corrected. The pH value of the mixed waters was not stated but was apparently under 7, however.

*Excerpts from a paper, of the same title, which was read before the Four States Section of the A. W. W. A.

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The Water Supply of Bermuda

The system which supplies the islands of Bermuda with fresh water was the subject of discussion at a recent meeting of the American Section of the Society of Chemical Industry, held jointly with the American Chemical Society, the Electrochemical Society and the Societe de Chimie Industrielle at the Chemists' Club, 52 East 41st St., New York City.

Dr. W. D. Turner, of Columbia University, who developed the system, presented a paper entitled "The Bermuda Water Works," in which he described the special installation made necessary by the soil conditions peculiar to the islands.

Until 1929 Bermuda had to depend entirely for fresh water on importations from New York or on rain water collected from the roofs or specially constructed catchments. This was necessary because no method had been found to collect underground fresh water without salt contamination from the sea water which permeated the coral structure of the islands.

Dr. Turner, on a visit to the islands, conceived the idea of applying horizontal wells or infiltration galleries for collecting the surface waters. The system produced water free from salt but very hard, due to percolation through the coral sandstone. This system was therefore supplemented by an extensive softening process, and the resultant soft, fresh, pure water is now being produced and distributed throughout the colony in a complete system of asbestos water mains designed to be resisant to the serious corrosion conditions existing in these subtropical sea islands.

ELIMINATING AIR IN FILTERS AT WINNETKA

By CARL LEIPOLD

Superintendent of Filtration, Winnetka, Ill.

THE accumulation of air in the rapid sand filters at Winnetka occurs at periods of low water temperatures (33 to 38 degrees F.). On December 13, 1932, at the start of washing No. 1 filter, an unuaslly large amount of air came up through the filter sand. The filter influent water temperature for the four preceding days was 34, 34, 34 and 33 degrees Fahrenheit.

An investigation indicated that the pipe gallery heating system was the cause for the unusually large amount of air in this filter. The filters are washed by a motor driven centrifugal pump which takes its suction from the filtered water reservoir. The pipe gallery is heated by a unit heater having two speeds with capacities of 246,000 B.T.U. per hour, 1025 sq. ft. equivalent direct radiation and 4300 C.F.M. air delivery at low speed and 302,000 B.T.U. per hour, 1260 sq. ft. equivalent direct radiation and 5740 C.F.M. air delivery at high speed with 2 lbs. per sq. in. gage steam pressure. This unit heater is located above the wash water line (Fig. 1) with the louvres adjusted to throw the heat at a 45 degree angle.

The results of the investigation showed that a 24-hour period had occurred between filter washings with the unit heater operating at full speed. The heat applied by the unit heater to the wash water piping and filter effluent piping had changed the temperature of the stagnant water inside of these lines resulting in liberation of the dissolved gases from the water.

Automatic air relief valves were assembled as shown in Figs. 1 and 2, to eliminate air in the pipe lines during the periods between filter washings and the periods of plant shut-downs. The method now used for washing a filter is to place the wash water pump into operation leaving the filter wash water valve closed for one minute which has been found to be sufficient time to force the air out of the wash water line and through the automatic air relief valves. Any air collecting at the elbow on the filter side of the wash water valve, will be forced out, through the automatic air relief valve by the head of water from the filter (Fig. 2).

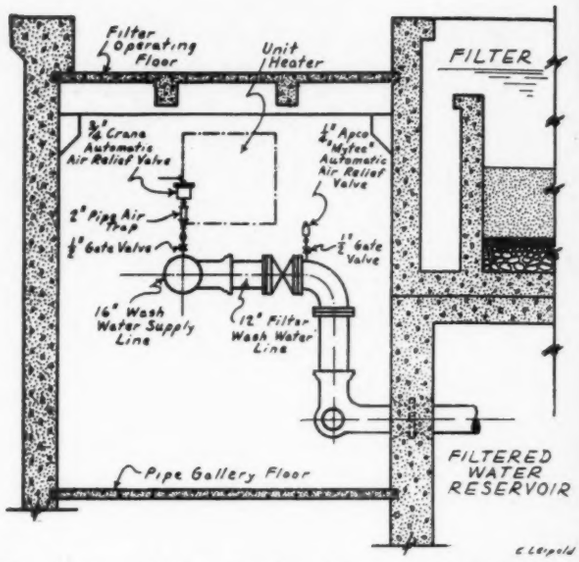


Fig. 2—Cross Section Showing Automatic Air Relief Valve Connections

The results of this assembly have shown that the heating system used for the pipe gallery should be arranged to apply the heat from many small heating units rather than one unit only. Also, the heating units should be placed as far away as possible from the wash water line filter effluent piping and filter rate control equipment.

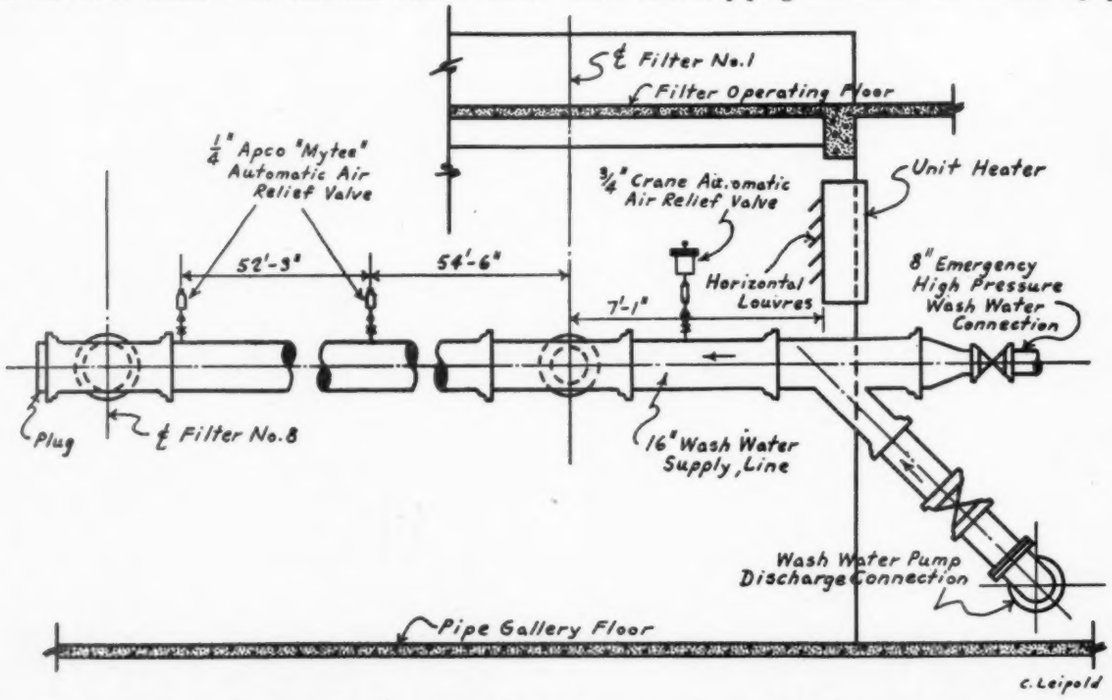


Fig. 1—Cross Section Showing Automatic Air Relief Valve Connections to Wash Water Supply Line and Location of Pipe Gallery Unit Heater

MEETING OF SOUTHEASTERN SECTION OF A. W. W. A.

(South Carolina—Georgia—Alabama—Mississippi)

THE Southeastern Section of the A. W. W. A. (formerly Southeastern Water Works Association) held its annual meeting in characteristic fashion at the Partridge Inn in Augusta, Ga., on April 10, 11, and 12. The official registration was 185 but the barbeque and the "speechless" dinner, followed by entertainment and dancing, was attended by more than 300.

Golfing weather was tip-top in Augusta, and the tournament, being played by 50, was staged on the famous Augusta National Course. Low gross score, among active members, was made by F. W. Chapman, Supt. Water Works at Greenwood, S. C., while among the associate members (manufacturers representatives) A. S. Goss led the field.

R. E. Findlay, Secretary-Treasurer, Board of Water Commissioners, Macon, Ga., Chairman of the Section.

Officers elected for the ensuing year were:

Chairman—R. E. Findlay, Secy.-Treas. Water Commission, Macon, Ga.

Vice-Chairman — J. W. Lovejoy, Supt. Water and Lighting System, Lawrence, S. C.

Secy.-Treas.—W. H. Weir, Engineer, State Board of Health, Atlanta, Ga.

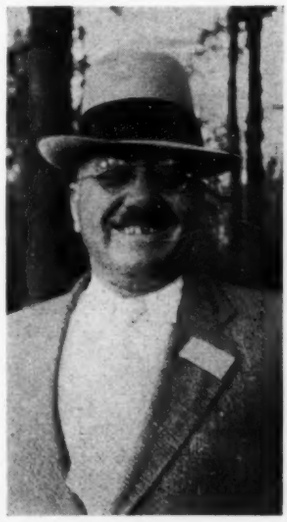
Trustees — A. Clinton Decker, Birmingham, Ala.; A. J. Smalshaf, Columbus, Ga.; L. P. Tobin, Camden, S. C.

Director of the A. W. W. A.—W. H. Weir, Atlanta, Georgia.

Technical Sessions

(Chairman—J. K. Marquis, Presiding)

Considering the wonderful spring weather and the lure of an exceptional golf course the technical sessions were well attended. Maybe that was because Brother C. H. Hunnicutt, Chairman of the Macon, Ga., Water Commission, was on the program and the members knew that there would be nothing "dry" in his discussion.



J. K. Marquis, Superintendent, Filtration, Spartanburg, S. C., Retiring Chairman.

"Reconstruction of the Riverside Station at Macon, Ga."—T. E. P. Woodward, Chief Engineer, Water Department, Macon, Ga.

Mr. Woodward described the pumping station and filter plant which the city of Macon had purchased from a private company, only to find that poor design and obsolescence made it necessary to reconstruct and revamp the plants. He described a series of well planned improvements subject to financing from income, to be put through as rapidly as practicable and in order of importance. The first work had already been completed, without issue of bonds, at a cost of $300,000. It involved new raw-water pumps, reconstruction of filters, new mechanical mixing chambers (25 min. detention), chemical house, laboratory. Automatic boiler stokers and turbine driven pumps of 10 m.g.d. (5 m.g.d. output) for high service duty, previously installed, had lowered pumping costs and was saving thereby $8,000 per year. The new units consisting of three single stage De Laval pumps connected in series—low service water being taken off beyond the second pump, with the remainder passing through the third stage to the high service system.

In the new underdrain system in the filters a central concrete manifold was employed. Corrosiveness of Macon water had justified use of drilled copper piping for laterals, at an added cost of only $50.00 per m.g.d. filter capacity. Metering the system 100 per cent had brought consumption down to 5 m.g.d.

C. H. Hunnicutt, Chairman of Water Commission, Macon, Ga., praised the careful planning of the city's engineers, Weideman and Singleton, and the work of Mr. Woodward. He said that in Macon a water main extension must yield a net return of at least 15 per cent on the investment. On the recent project they had accumulated $190,000 in cash to spend and had gotten PWA assistance to the extent of $36,000—yet to be collected, however. Delinquent accounts (750) had mounted to $5,000 but by going after partial payments and the use of the "turnkey" the $5,000 had been reduced to $2,000. Some consumers responded to reason; others had to be treated a little rough at first.

"Handling and Storage of Water Works Chemicals"—L. L. Hedgepeth, Engineer, Pennsylvania Salt Mfg. Co., Philadelphia, Pa.

Mr. Hedgepeth in a thoroughly prepared paper, which was distributed in mimeographed form, set forth the physical and chemical behavior of water works chemicals. Concerning ammonia and chlorine, he gave some timely suggestions pertaining to their handling and use. The major part of his talk was illustrated by lantern slides picturing the mechanism of liquefaction of chlorine gas in piping leading to chlorinators and how to avoid "splitting" chlorinators by preventing such liquefaction. Also he pictured the more common causes of blockage of chlorine lines and small orifices—one in particular being that of leaking oil from pressure gages into the chlorine lines. Too rapid evaporation (distillation) of liquid chlorine from a container would add to the chances of line and chlorinator fouling. He pointed out the great volume expansion of liquid chlorine with temperature rise and the remarkably slight drop in temperature required to produce liquefaction of gas at the chlorinator when warmth of the chlorine container resulted in high pressures on the gas lines to chlorinators. On the screen he showed modern and approved schemes of safe and easy handling of one ton chlorine containers at water and sewage plants.

L. H. Enslow in discussion said that liquefaction in chlorine lines was preventable by installing a pressure

control (reducing) valve near the chlorine container, thereby reducing the pressure below the critical (liquefaction) point for temperatures down to freezing. As safe practice, he would recommend that every plant procure and keep on hand a spare standard cylinder valve or two, which could be used to replace defective or leaking valves if necessary. To change a valve the pressure on the container could be brought to a very low point by placing the cylinder or ton container in a salt and ice pack such as used by ice cream and refrigeration plants. Then, out of doors, the valve could be removed and a new one screwed in with no hazard and but little inconvenience. Packing with so called "dry-ice," if available, was more rapid and complete in effect but required care to avoid frosting the hands during the handling. For ease and safety in handling 150 lb. cylinders Mr. Enslow called attention to the use of light weight hospital hand trucks such as are used for moving cylinders of oxygen from point to point (see WATER WORKS AND SEWERAGE Sept., 1933, p. 322). Every chlorine storage or chlorinator room should be equipped with a high capacity exhaust blower discharging away from the building. One or more dependable gas masks should be kept in a handy location *outside* the chlorine room. In case of exposure to chlorine the patient would find breathing of benzoin-

T. E. P. Woodward, Chief Engineer, Water Department, Macon, Ga.

L. L. Hedgepeth, Engineer, Pennsylvania Salt Mfg. Co., Philadelphia.

steam vapor very soothing. The treatment is the same as that used as an old family remedy in croup and other respiratory troubles. A bottle of tincture of benzoin was a useful thing to have on hand in the first aid kit.

Round Table Topics

"Open vs. Closed Reservoirs"—FRANK W. CHAPMAN, Supt. Water Works, Greenwood, S. C.

Mr. Chapman told of troubles with algae which had been eliminated by covering an open reservoir with light weight corrugated asbestos roofing and guniting around the sides. He had become an advocate of covered clear water reservoirs which had other advantages aside from elimination of algae.

RHETT PRINGLE, Supt., Water Works, Thomasville, Ga., had algae troubles which had been eliminated less expensively by carrying residual chlorine in the open reservoir.

J. L. HAWKINS, Assistant Superintendent at Greenville, S. C., reported success also with chlorination involving the use of ammonia in ratio of a 0.25 p.p.m. NH_3 and 0.4 p.p.m. chlorine. Others, however, had not had the same success.

H. W. SCHUMPERT, Superintendent at Newberry, S. C., remarked that ammonia regulation was important in algae control—too much causing an increase in algae growth if the proper residual chlorine was not provided or after the chlorine had been used up.

"Carbon Dioxide Removal and Corrosion"—H. F. WIEDEMAN, Consulting Engineer, Atlanta, Ga.

Mr. Wiedeman discussed the mechanics of corrosion and tuberculation of water mains. Alkalinity, carbon dioxide and oxygen were the important factors to consider in corrosion control, the latter possibly being blamed for more than its fair share of corrosion. The simplest correctives for corrosion were the removal of carbon dioxide by aeration, addition of alkali or both. Complete corrosion control would be best secured by keeping the water from contact with the metal by use of pipe coatings or linings or laying down a carbonate film by increasing the hardness and alkalinity of the water. He discussed various aeration schemes, nozzles, step aerators and diffused air, such as provided by porous media or the Aeromix device. The passage of soft waters through crushed limestone beds (35 minute contact) constituted another scheme of taking out free carbon dioxide and adding hardness in corrosion control.

JAS. E. GIBSON, General Manager, Water Commission, Charleston, S. C., said that waters lower than 40 p.p.m. in alkalinity and 30 in hardness would give corrosion troubles even when the pH was increased to 8.4 or somewhat higher. Cement lined mains and copper service piping were advocated in such instances, where the increasing of alkalinity would not prove sufficient. They at Charleston used caustic soda to raise the pH and an aerator employing low head (3 ft.) Yarway involute type nozzles had been installed to reduce odors and CO_2 in the raw water after alum and sodium aluminate additions. Copper sulphate was added to the raw water at times also. "Nuchar" activated carbon was employed to stabilize sludge and assist in taste control. Prechlorination was practiced to improve coagulation. The filter effluent would show a color of 5 p.p.m. which upon exposure to sunlight in an open reservoir increased to 15 p.p.m.

"Improved Designs and Painting of Elevated Tanks"—JOHN M. PERRYMAN, Engineer, R. D. Cole Manufacturing Company, Newman, Ga.

Mr. Perryman pointed out improved design features in recent elevated tank installations which embodied improvement in appearance of these utility structures at little if any added cost. His talk was illustrated by specific installations to show pleasing and unusual tank design embellished by flood light effects from beneath. Recent economy in tank design, with improved appearance, had resulted from reduction of depth and improved top as well as bottom design. One interesting design consisted of a sperical tank of 30 ft. diameter (100,000 gals. capacity) mounted on a pedestal of 15 ft. diameter at its base which housed the pumping station. While failure of elevated tanks in catastrophies was rare, he stated that the faulty foundation of one tank at an industrial plant had been responsible for the death of several men. A 10 year sentence is now being served by the engineer responsible.

MR. GIBSON said that an outgrown distribution system could be materially benefited by installation of an elevated tank as near its center as practicable. The tank of 2 m.g. capacity in Charleston had been a lifesaver.

MR. PERRYMAN had found the most satisfactory paint job on tanks to consist of thorough cleaning with wire brushes to the bright metal followed by red lead priming coats and aluminum paint as the finishing coats. He warned against using an asphalt base aluminum paint. The asphalt would creep through to the surface in time and spoil the appearance of the job.

S. C. HAMILTON, Chicago Bridge and Iron Works,

Columbia, S. C., said that olive green and bronze paint had been very effectively used to subdue and harmonize elevated tanks with their surroundings. Specifications for painting tanks and standpipes had been drawn by a committee of the New England and the American Water Works Associations and copies were available.

Mr. Gibson remarked that some study had been given the matter before painting the Charleston tank. They had decided on the hot application of Bitumastic compound. The manufacturers (Wailes, Dove, Hermiston Company) had applied a coating ¼ inch thick to the inside of the tank in June, 1926, and recent inspection had shown it to be as good as when put on. The exterior had been painted with an aluminum-bakelite varnish to give long service and improved appearance.

M. C. Smith, Engineer of Water and Electricity, Richmond, Va., called attention to the thorough tests of paints for tank interiors which had been conducted by the Pittsburgh Des Moines Steel Company. The rating of paints and coatings had been published in a recent bulletin put out by this company. Highest ratings went to paints with a bakelite varnish base and to Bitumastic coatings, applied hot.

The "Round Table" was closed with a discussion of "Handling Customer Complaints" led by L. E. Findlay of Macon, Ga., in which it was apparent that kind words turneth away much wrath and that a little money spent in tidying up and beautifying water works properties did perhaps more than any one thing to build up good will of the public toward the utility. Mr. Gibson pointed out that experiences at Charleston had demonstrated this fact repeatedly.

Soil Corrosion Studies

"Underground Corrosion in the Southeastern States"—K. H. Logan, Engineer, Bureau of Standards, Washington, D. C.

Mr. Logan stated that localized underground corrosion could be explained most easily by variations in the

H. F. Wiedeman, Consulting Engineer, Atlanta, Ga.

"Beek" Little, Secretary, A.W.W.A., and "Bill" Weir, Secretary and Director, Southeastern Section.

oxygen supply in contact with the metal, rather than to inherent differences in the structures or variations in impurities in the metal. Unrecognized conditions modify rates of corrosion and may readily mislead one in drawing conclusions as to resistance of various metals to soil corrosion because, a test under different conditions might easily reverse the earlier decision. Underground corrosion proceeding rapidly at the start slows down materially and the corrosion rate curve flattens out due to protective corrosion products and then becomes proportional to time. Higher temperatures, higher moisture

Waiting for "Chow" at the Barbecue: M. H. Collins (Louisville, Ky.) Listens with Interest to J. E. Gibson (left) Telling How It Was in Those Days.

content and greater acidity are favorable to increasing corrosion rates. To reduce corrosion losses, protective coatings appear sounder economically than attempting to substitute the more costly resistant metals. For ferrous pipes, zinc, cement and bituminous coatings are the most effective. Cathodic protection of pipe lines, insulated from the soil, constitutes a new method now receiving favorable comment.

Localized corrosion may best be explained by the setting up of differences in electric potential at the metallic surface.

"Flow of Small Streams"—B. M. Hall, Jr., Engineer-Examiner, P.W.A., Atlanta, Ga.

Mr. Hall outlined methods commonly employed in measuring stream flows with particular reference to small streams. Various types of weirs and current meters were discussed as were the best methods to pursue in taking flow measurements.

Other papers* presented were:

"Putting Plan Into Our Future"—H. T. McIntosh, Regional Chairman, National Planning Board, Albany, Ga.

"Trends in Stream Pollution Research and Control"—J. K. Hoskins, U. S. P. H. S., Cincinnati, Ohio.

"Methods of Sewage Treatment—Their Object and Utility"—M. T. Singleton, Consulting Engineer, Atlanta, Ga.

▼

Harry R. Hall Elected Chairman of 4 States Section A. W. W. A.

The following were named officers of the 4 States Section of the A. W. W. A. at its recent meeting held in Philadelphia:

Chairman—Harry R. Hall, Asst. Chief Engr., Washington Suburban Sanitary District, Hyattsville, Md.

Vice Chairman—W. Compton Wills, Supt. Water Works, Wilmington, Del.

Sec'y.-Treas.—Chas. H. Becker, R. D. Wood Co., Philadelphia, Pa.

Trustee—W. R. Conard, Cons. Engr., Burlington, N. J.

Trustee—H. M. Freeburn, District Engr., Penna. Dept. Health, Philadelphia, Pa.

*With apologies to the authors, we regret our inability to report their papers in the space available.—*Editor.*

TURNING THE CORNER IN WATER CONSUMPTION

By CHARLES H. CAPEN, JR.

Consulting Engineer, West Orange, N. J.

Chas. H. Capen, Jr.

DURING times of prosperity, any increase in the use of various commodities is emblazoned at the top of columns in the stock market reports of newspapers and periodicals. The same is true of the use of electric power, gas production and other utility statistics. When financial conditions cause a recession in the use of all these items, the decrease is not given such wide advertising.

In the water works field, due mainly to the fact that the preponderance of ownership is in the hands of municipalities, the actual consumption and earnings are given little notoriety. For the purpose of drawing attention to the effect of the recent depression on the consumption of water, curves have been drawn and are herewith presented for the purpose of picturing the parallel that can be drawn between the water supply business and general business conditions.

The figures used to produce this evidence were taken from records of various supplies in the northeastern part of New Jersey. There are in this territory 39 individual water supplies delivering water to 150 separate municipalities which vary from strictly residential communities to large industrial cities.

At the close of the business recession of 1921, water consumption in this area started a rapid and uninterrupted series of yearly increases, up to and including 1929. Compared with the 1929 level, the volume of water used in 1930 showed a reduction of only about one per cent, in 1931 nearly 7 per cent, in 1932 12½ per cent and in 1933 about 18 per cent.

In the absence of further data, it might be inferred that decrease was still in progress at the end of 1933. In order to determine the exact status, however, a monthly analysis is necessary. Figure 1 pictures in composite form the water consumption in areas served by the twelve largest works and represents about 75 per cent of the total water supplied the district. (Certain omissions have been made in the case of some of the municipalities served by these twelve sources as special conditions occurred there which would distort the conclusions as to the general trend.) Here it may be clearly seen that up to the month of October the consumption in 1933 was following a definitely lower course than in 1932. Then a noticeable change occurred and since that date a definite turn toward an increase in consumption has been noted.

Unquestionably the severely cold winter of 1933 and 1934 had a marked effect in advancing the rate of domestic water consumption in the last few days of 1933 and the first quarter of 1934. Faucets left running to prevent freezing had their influence. To discount this at a time of increasing consumption is a problem which cannot be accurately solved but is susceptible of some approximations.

In order to compensate for the effect of cold weather, the figures for some of the suburban communities, wherein the rates of consumption in 1933 were almost identical with those of the preceding few years, were studied. These indicated that the average increase in the first quarter of 1934 over the corresponding period in 1933 was 5 per cent, this increase being truly attributable to cold weather conditions. After having examined records and discussed the matter with various water works men in the territory, it is the conclusion of the writer that an increase of not more than 8 per cent would represent the normal average cold weather effect in the district.

Having arrived at this conclusion, it is then possible to view the records without being misled by abnormal conditions. Table I, covering several supplies, shows the average rates of consumption for the first quarter of the years 1932, 1933 and 1934. One of these, East Orange, is almost wholly a residential community. Of the others, all supply some industrial areas. Assuming a cold weather effect of 8 per cent, it becomes evident that the net consumption for the first quarter of 1934 is from 2 to 15 per cent greater than for the corresponding period in 1933.

The case may be rested here. Further comment is scarcely necessary except to point out that in a statement

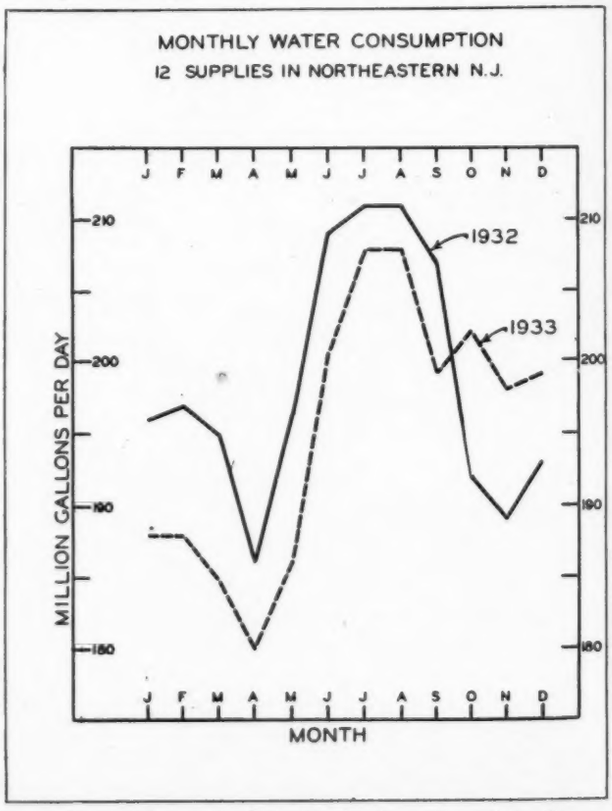


Fig. 1.—Water Consumption in Areas Served by 12 Largest Works.

TABLE I.—WATER CONSUMPTION OF VARIOUS SUPPLIES IN NORTH-EASTERN NEW JERSEY

Supply	Average Million Gallons per day for first quarter of 1932	1933	1934	Per Cent Increase 1934 over 1933
East Orange	4.63	4.58	4.81	4.9
Elizabethtown Water Co.	7.41	7.81	9.56	22.4
Hackensack Water Co.	31.6	30.2	33.3	10.2
Jersey City	55.9	50.3	57.8	14.8
Middlesex Water Co.	5.73	5.06	6.23	23.1
Newark	48.4	46.6	54.0	15.9
New Brunswick	5.58	5.19	6.31	21.6
Perth Amboy	4.49	4.42	5.18	17.2
Plainfield-Union Water Co.	4.96	4.78	5.30	10.8
Total	168.70	158.94	182.49	14.8

Revised as of April 26, 1934.

appearing in the newspapers, it was shown that telephone installations in New York City started to show an increase in September, 1933; and, the use of gas and electricity increased similarly at about the same time.

The following conclusions may be drawn:

(1) Water consumption serves as a barometer of business conditions, just as does the consumption of commodities and the products of other utilities.

(2) The decrease and increase is primarily a function of changing industrial consumption of water.

(3) The corner has been turned in water consumption.

▼

Corrosion Survey for Pipe Lines

In a paper entitled "Corrosion Surveys for Pipe Lines and Distribution Systems," presented at the distribution conference of the American Gas Association in Detroit on April 10 by Scott Ewing, an attempt is made to determine whether or not any of the methods which have been proposed for locating corrosive soils are sufficiently reliable to be recommended for general use. The Technical News Bulletin for April briefs the paper as follows: These methods may be divided into 3 general classes: (1) electrical methods, in all of which the soil resistivity is the most important factor; (2) chemical methods, of which the measurement of soil acidity is the only one considered in this paper; and (3) soil classification methods which include field examination of the soil, the topography, drainage, vegetation, etc.

A method of treating the data has been devised whereby, with assumed coating and repair costs, the saving which could have been effected by coating certain parts of the line at the time the line was laid can be determined. Any of the proposed survey methods may be tested on an old line the corrosion history of which is known.

The data upon which this report is based include superficial surveys of 2 large gas distribution systems and a rather detailed survey of about 1,000 miles of transmission lines, for which accurate repair records had been kept.

The results show that the most accurate method for making a corrosion survey includes mapping the soil types and collecting samples upon which acidity and resistivity measurements are made.

The report describes the procedure to be followed in making the survey for a new pipe line, and the method of determining where coatings should be applied. It is believed the method could be used in most midwestern, eastern, and southern soils, but it will certainly require modification in western soils.

The Drought in England

According to a special article in the New York Times, the chairman of the London Water Board has caused a letter to be sent to more than a million householders, warning them that unless they cooperate voluntarily with the board in cutting down the consumption of water, special measures will have to be taken to avert a water famine in the metropolis.

Water has become a precious thing in England. For more than a year no rain of importance has fallen. The drought comes on top of a long rainless period of a year earlier. The government has asked Parliament for emergency powers, overriding local authorities and permitting national control of the British water supply. The prolongation of the drought may place England in the situation of Egypt.

It is seventy-six years since there has been such a scarity of water in the realm. Unless rain falls soon in torrents and for several weeks on end, people in many towns and villages will have to give up baths, and the watering of cattle will become a problem.

The response to the appeal of the water board has been typically British. Plumbers have been busy with requests to attend to leaking taps, hose pipes have been employed less, and bathing has been on a less extravagant scale. This is proved by the fact that in a week's time the London consumption, normally 300 million gallons a day, was reduced by nearly 10 per cent. The board has expressed its gratification with the result. It hopes that in these circumstances it will not be necessary to restrict the use of water further for three or four months to come, at least.

March, 1933, was the last month when the rainfall was normal. Since then, especially in the Western counties, only slight rains have fallen, and, generally, there have been five periods of absolute drought, lasting from sixteen days to a month. The government intends to spend about a million pounds on various plans for the storage and better distribution of water supplies. Water is being nationalized.

In 1921 England had a foretaste of the present drought, yet conditions then were not severe as they are now, because reserves had accumulated in the soil in a series of rainy years. But 1934 comes as the culmination of a number of dry years.

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W. W. Brush to Retire After 40 Years' Service

W. W. Brush has announced his intention to retire from the position of Chief Engineer of the Bureau of Water Supply of New York City on June 1st. Mr. Brush has been in the service of the city as water supply engineer for a period of 40 years, having served as deputy and then Chief Engineer for the past 24 years.

Mr. Brush has become an outstanding authority on water supply practices and has also served the American Water Works Association, of which he has been treasurer for a number of years, in many important ways.

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CONTRACT TO BE LET SOON FOR GRAND COULEE DAM.—The Columbia Basin Commission will open bids on June 18 for the construction of the Grand Coulee dam and power plant of the Columbia Basin Project, Washington. The work is located near Almira, Wash., and will require 11,450,000 cu. yds. of open cut excavation and 3,260,000 cu. yd. of concrete.

AMERICAN WATER WORKS ASSOCIATION

54th Annual Convention, June 4 to 8, 1934—Hotel Commodore, Headquarters, New York, N. Y.

Program

MONDAY FORENOON

*8:00 Registration.

9:00 East Ball Room. Conference on Proposal for Code for the Water Supply Industry.

10:00 Room B. Presiding Officers of Sessions.

Main Session, East Ball Room

11:00 Opening of Convention. MALCOLM PIRNIE, President. Announcement of Officers, Reports, Award of Medals and Prizes.

MONDAY AFTERNOON

Main Session, East Ball Room

2:00 Plant Management and Operation Division.
CARL A. HECHMER (Chairman), Dept. Engr., Maintenance and Operating Dept., Washington Suburban Sanitary District, Hyattsville, Md.
Superintedents' Round Table Discussion.

MONDAY AFTERNOON (Continued)

Water Purification Division, West Ball Room

GEORGE D. NORCOM (Chairman), Federal Water Service Corp., New York, N. Y.

2:00 Special Conference.
Report of Committee on Specifications and Methods of Analysis for Water Purification Chemicals.
MATHEW M. BRAIDECH (Presiding), Senior Chemist, Baldwin Filtration Plant, Cleveland, O.
Discussion by:
A. M. BUSWELL, CARL J. LAUTER, WILLIAM M. WALLACE, LEWIS I. BIRDSALL, AUGUST G. NOLTE.

**5:00 Room B. Board of Directors.

*Registration desk opens Sunday evening. Congestion and delay to members can be avoided by registration in advance by mail. All members will receive cards by mail.

**First meeting of the Board of Directors will be held at 8:00 p. m. Sunday.

MONDAY EVENING

6:30 Dinner. "Service des Eaux."

9:00 Informal Reception and Dance. East Ball Room.

TUESDAY FORENOON

Main Session, East Ball Room

9:30 Features of New York City's Water Program.
WM. W. BRUSH, Chief Engineer, Dept. of Water Supply, Gas and Electricity, New York, N. Y.
Discussion led by:
THADDEUS MERRIMAN, Chief Engr., Board of Water Supply, New York, N. Y.

10:15 Pipe Corrosion Experiments, Catskill Supply, New York City.
FRANK E. HALE, Director of Laboratories, Dept. of Water Supply of New York City, Brooklyn, N. Y.

11:00 Water Works and the P. W. A. Outlook.
WILLARD T. CHEVALIER, Publishing Director, *Engineering News-Record*, New York, N. Y.
Discussion led by:
ABEL WOLMAN, Chief Engr., State Dept. of Health, Baltimore, Md.

TUESDAY FORENOON (Continued)

Finance and Accounting Division, West Ball Room

E. E. BANKSON (Chairman), J. N. Chester Engineers, Pittsburgh, Pa.

9:30 Changes in Federal Tax Laws Affecting Water Companies.
LOUIS D. BLUM, Certified Public Accountant, New York, N. Y.

10:00 Taxation as Applied to Municipally Owned Water Works.
A. C. KAMPLAIN, Meter Service Co., Valparaiso, Ind.
Discussion led by:
E. J. FRICKER, Hackensack Water Co., Weehawken, N. J.

10:40 A Property Record for Investment in Fixed Capital.
F. C. HAMILTON, Member of Executive Committee, Henry L. Doherty Co., New York, N. Y.
Discussion led by:
C. J. ALFKE, Comptroller, Hackensack Water Co., Weehawken, N. J.

11:20 Work Incentives.
HAL SMITH, Supt., Water Consumer Accounts, Dept. of Water Supply, Detroit, Mich.

12:00 Mechanical Aids to Scientific Office Management.
W. P. ADAMS, Public Utilities Div., Burroughs Adding Machine Co., Detroit, Mich.

12:30 Luncheon. Finance and Accounting Division.
Speaker, E. E. BANKSON, Future Work of the Division.
Election of Officers.

TUESDAY FORENOON (Continued)

10:00 Room A. Committee on Boiler Feed Water Studies.
SHEPPARD T. POWELL (Chairman), Cons. Chem. Engr., Baltimore, Md.

10:30 Trip for Ladies to Macy Store.

1:00 Ladies' Luncheon Bridge.

TUESDAY AFTERNOON

Main Session, East Ball Room

2:00 Direct Purchase of Materials for Construction Contracts Versus Purchase Through Contractor.
PAUL HANSEN, Greeley & Hansen, Hydr. and San. Engrs., Chicago, Ill.
Discussion led by:
L. R. HOWSON, Alvord, Burdick & Howson, Cons. Engrs., Chicago, Ill.

2:40 New Questions of Law and Policy in the Making of Rates for Water Service.
W. L. RANSON, Attorney-at-Law, New York, N. Y.

3:20 Recent Tendencies in Relation to Valuation of Water Rights.
ROBERT E. HORTON, Cons. Engr., Voorheesville, N. Y.
Discussion led by:
CHARLES W. SHERMAN, Metcalf & Eddy, Cons. Engrs., Boston, Mass.

4:00 Tests of Friction Loss in Distribution Piping.
BURT B. HODGMAN, National Water Main Cleaning Co., New York, N. Y.
Discussion led by:
EDGAR K. WILSON, Chief Engr., Pitometer Co., New York, N. Y.

TUESDAY AFTERNOON (Continued)

Water Purification Division, West Ball Room

2:00 Determination of Odors and Tastes in Water by the Air Dilution Method.
GORDON M. FAIR, Assoc. Prof. of San. Engineering, Harvard University, Cambridge, Mass.
Discussion led by:
M. WARREN COWLES, San. Engr., Hackensack Water Co., New Milford, N. J.

2:30 Occurrence and Control of Iron Bacteria in Water Supplies.
KENNETH W. BROWN, San. Engr., California Water Service Co., Stockton, Calif.
Discussion led by:
FRANK E. HALE, Director of Laboratories, Dept. of Water Supply of New York City, Brooklyn, N. Y.

3:00 The Spectographic Analysis of Water.
MATHEW M. BRAIDECH, Senior Chemist, Baldwin Filtration Plant, Cleveland, O.
Discussion led by:
EDWARD BARTOW, Prof. of Chemistry and Chem. Engineering, University of Iowa, Iowa City, Ia.

3:30 Report of Committee on Testing Zeolites.
CHARLES P. HOOVER (Chairman), Chemist, Filtration Plant, Columbus, O.
Discussion led by:
JACK J. HINMAN, JR., Assoc. Prof. of Sanitation, University of Iowa, Iowa City, Ia.

4:00 Report of Committee on Filtering Materials.
FRANK W. HERRING (Chairman), Asst. Editor, *Engineering News-Record,* New York, N. Y.
Discussion led by:
G. GALE DIXON, Cons. Engr., Youngstown, O.

TUESDAY EVENING

6:45 Dinner. Water Purification Division.

WEDNESDAY FORENOON

Main Session, East Ball Room

Plant Management and Operation Division.

9:30 Outstanding Factors in Underground Water Waste Surveys.
FRED B. NELSON, C. E., Dept. of Water Supply, New York, N. Y.
Discussion led by:
JUSTUS B. EDDY, Engr., Water Pipe Extension, Chicago, Ill.

10:10 Thawing Frozen Service Pipes.
REEVES J. NEWSON, Pres. Community Water Service Co., New York, N. Y.
Discussion led by:
J. ARTHUR JENSEN, Supervisor, Water Works Dept., Minneapolis, Minn.

10:50 Superintendents' Round Table Discussion.

WEDNESDAY FORENOON (Continued)

Water Purification Division, West Ball Room

SYMPOSIUM ON CHLORINATION

A. The Mechanics of Chlorination

9:30 Equipment for the Application and Control of Chlorination in Small Water Supplies.
CHARLES R. COX, Assoc. Engr., State Dept. of Health, Albany, N. Y.

9:45 Handling Chlorine to Avoid Trouble.
L. L. HEDGEPETH, Mgr., Technical Service Dept., Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Discussion led by:
CHARLES E. TROWBRIDGE, San. Engr., American Water Works & Electric Co., Inc., New York, N. Y.

B. The Ammonia-Chlorine Process

10:15 Review of the Status of the Ammonia-Chlorine Process.
M. C. SMITH, Engineer in Charge, Bureau of Water and Electricity, Richmond, Va.

10:30 A Study of the Efficiency of the Ammonia-Chlorine Process.
ATTMORE E. GRIFFIN, Chemist, Wallace & Tiernan, Inc., Belleville, N. J.
Discussion led by:
HARRY E. JORDAN, San. Engr., Indianapolis Water Co., Indianapolis, Ind.

C. The Orthotolidine Test for Residual Chlorine Application and Limitations

11:00 Interference of Manganese with the Orthotolidine Test.
A. M. BUSWELL, Chief, State Water Survey Division, Urbana, Ill.

11:15 Interference of Forms of Nitrogen with the Orthotolidine Test.
ROBERTS HULBERT, Senior Chemist, Filtration Plant, Detroit, Mich.
Discussion led by:
C. A. HOLMQUIST, Director, Div. of Sanitation, State Dept. of Health, Albany, N. Y.

11:45 A Review of the Entire Discussion.
LINN H. ENSLOW, Editor, WATER WORKS AND SEWERAGE, New York, N. Y.
General Discussion.

WEDNESDAY AFTERNOON

Joint Session of General Membership and Water Purification Division, East Ball Room

2:00 Coagulation with Iron Compounds.
A. P. BLACK, Prof. of Chemistry, University of Florida, Gainesville, Fla.
Discussion led by:
ROBERT W. SAWYER, with Malcolm Pirnie, Cons. Engr., New York, N. Y.

2:30 Amebic Dysentery in Relation to Water Purification.
THORNDIKE SAVILLE, Prof. of Hydr. and San. Engineering, New York University, New York, N. Y.

2:50 Significant Features of the Chicago Amebic Dysentery Outbreak.
A. Engineering.
JOEL I. CONNOLLY, San. Engr., Bureau of Engineering, Chicago, Ill.
B. Epidemiology.
ARTHUR E. GORMAN, Engr. of Filtration, Bureau of Engineering, Chicago, Ill.
Discussion of above three papers led by:
ABEL WOLMAN, Chief Engr., State Dept. of Health, Baltimore, Md.

4:00 Round Table Discussion on Taste and Odor-Control.
JOHN R. BAYLIS (Leader), Physical Chemist, Bureau of Engineering, Chicago, Ill.
Discussion by:
ALFRED ECKERT, Supt. of Filtration, Water Works, Saginaw, Mich.
GEORGE R. SPALDING, Asst. Supt. of Filtration and Sanitation, Hackensack Water Co., New Milford, N. J.
NORMAN J. HOWARD, Director of Water Purification, Island Filtration Laboratories, Toronto, Ont., Canada.

WEDNESDAY AFTERNOON (Continued)

Finance and Accounting Division, West Ball Room

2:00 Financial History of Water Department of City of New York.
JOSEPH GOODMAN, Asst. Engr., Bureau of Water Supply, New York. N. Y.
Discussion led by:
JOHN H. MURDOCH, JR. (Pres., Pennsylvania Water Works Association), Uniontown Water Co., Washington, Pa.

2:40 Uniform Classification of Accounts Suitable for Municipal and Private Plants.
E. V. WILLIAMSON, Public Utility Accountant, Charleston, Va.
Discussion led by:
F. W. SCHULZ, Asst. Treas., Community Water Service Co., New York, N. Y.

3:20 Federal Securities Act in Relation to the Financing of Water Companies.
BERNE H. EVANS, Attorney-at-Law, Harrisburg, Pa.

3:50 Effective Publicity as a Means of Eliminating Water Waste.
H. L. MEITES, Supt., Bureau of Water, Dept. of Public Works, Chicago, Ill.

WEDNESDAY EVENING

8:15 Theater Party. Radio City Music Hall.

THURSDAY FORENOON

Main Session, East Ball Room

9:30 Milwaukee's Water Purification Problem.
J. P. SCHWADA, City Engr., Milwaukee, Wis.
Discussion led by:
JOHN R. BAYLIS, Physical Chemist, Bureau of Engineering, Chicago, Ill.

10:15 Automatic Pumping Equipment and Telephonic Supervision at Baltimore.
LEON SMALL, Water Engr., City Water Dept., Baltimore, Md.
(Discussion deferred until after succeeding paper.)

10:40 Telemetering—The Electrical Transmission of Gage and Meter Readings.
P. S. WILSON, Cons. Engr., Glen Ridge, N. J.

11:00 Discussion of above two papers led by:
Representatives of GENERAL ELECTRIC CO.; J. WESTFORD CUTLER, Wallace & Tiernan Co., Newark, N. J.; and D. J. PURDIE, Builders Iron Foundry, New York, N. Y.

10:30 Trip for Ladies to Macy Store.

THURSDAY AFTERNOON

2:15 Boat Ride.

THURSDAY EVENING

6:00 Room B. Board of Directors.

9:30 Smoker, Ladies Invited. Main Dining Room.

FRIDAY

Trip by bus to Kensico and Croton Dams—leaving 10 a. m., return to hotel 5:30 p. m. Luncheon will be served at "The Farm" on the Bronx River Parkway.

MORE INSTRUCTIVE AND BETTER EXHIBITS

Manufacturers, in displaying their products, are featuring new ideas and vying with one another to make their exhibit the most instructive of the lot.

A STUDY OF FILTERING MATERIALS FOR RAPID SAND FILTERS

PART 2

A New Method for Determining the Effective Size of Sand

By JOHN R. BAYLIS*

Physical Chemist, Bureau of Engineering, Chicago.

PREVIOUS efforts to modify the Hazen method of determining the effective size of sand for rapid sand filters was briefly reviewed in the first of this series of articles.[1] Several suggested modifications have received consideration within the past fifteen or twenty years, but none of them seemed to offer a worthwhile improvement over Hazen's method and were never adopted. Consequently nearly every one adheres to the "effective size" and "uniformity coefficient," as defined by Hazen, for specifying sand, even though there may be other stipulations in the specifications. Any substitute for this method which may be offered at the present time must have an abundance of evidence to show that the proposed method is better. The method should not be complicated, should not differ so widely from the Hazen method that past work cannot be compared fairly accurately with the new method, and it must give the true effect of the size and uniformity of the sand on filtration. It is believed that the method which will be described meets these requirements. It makes use of sieves for determining the size of the sand grains and in this respect is the same as the method Hazen used, but it takes into consideration a combination of sand sizes for determining the effective size.

The New Method

Sieving.—Dry a representative sample of the sand which has been washed clean, divide into halves, and keep dividing one of the portions until a portion weighing about 100 grams is obtained. Weigh the portion and place on sieves which have been nested according to size. A convenient set is composed of sieves having 10, 16, 20, 24, 30, 40, 50, 60, 80 and 100 meshes to the inch. The exact number of sieves used and the sizes of the openings is not important so long as the difference between the size of the openings in a sieve and that of the sieve of next larger size is not too great. The sieves should be calibrated by use of the Hazen method. The finest sieve used should not pass more than 0.5 per cent of the weight of the sample.

Shake by hand about one-half minute and remove from the nest of sieves any of the coarser sieves which do not retain any of the sand. Then, shake the sieves in a shaking machine for some specified time. The time should be at least 10 minutes, and 15 minutes is preferable. It is important that the time of shaking be at least that employed in calibrating the sieves by determining the size of the largest sand grains passing each.

Weighing and Plotting the Weights.—Weigh the portions of sand retained on each sieve and total the amount, which should be the same as the weight of the portion taken for the test. Determine the percentage of the sand which will pass each individual sieve. This is done by adding the weights of the material which has been caught on all sieves of finer mesh. Table 1 shows sieving analysis of a typical filter sand.

TABLE I.—SIEVE ANALYSIS OF MUSCATINE SAND PLACED IN FILTER D X-2

(September 4, 1933)

Sieve	Grams Retained on Sieve	Total Grams Passing Sieve	Per Cent Passing Sieve
10	0.0	100.6	100.0
16	0.0	100.6	100.0
20	3.4	97.2	96.5
24	27.6	69.6	69.3
30	52.2	17.4	17.3
40	15.6	1.8	1.8
50	1.6	.2	.2
Less than.... 50	.2		

1	Per Cent Size	.400 mm. dia.
2	Per Cent Size	.435 mm. dia.
4	Per Cent Size	.457 mm. dia.
8	Per Cent Size	.500 mm. dia.
16	Per Cent Size	.550 mm. dia.
32	Per Cent Size	.615 mm. dia.
64	Per Cent Size	.730 mm. dia.

Average of 1 to 16 per cent diameters	.470 mm.
Average of 1 to 32 per cent diameters	.495 mm.
Per cent of material of diameter lass than 1.5 times the 1 per cent size	.28
Diameter of effective size of the sand	.489 mm.

Plot the percentages passing the sieves on coordinate paper with the diameter in millimeters of the sieve opening (this is the diameter of the largest size grains which will pass the sieves) as one axis, and the percentage passing as the other axis. Use ordinary coordinate, logarithmic, or logarithmic-probability paper. As the latter usually gives a nearly straight line for most sands, it probably is the better to use. Pass a line through the points. Figure 1 shows plotting of the sieving analysis recorded in Table 1. From the graph determine the 1, 2, 4, 8, 16, 32 and 64 per cent sizes. In referring to a certain per cent size, it means that the material con-

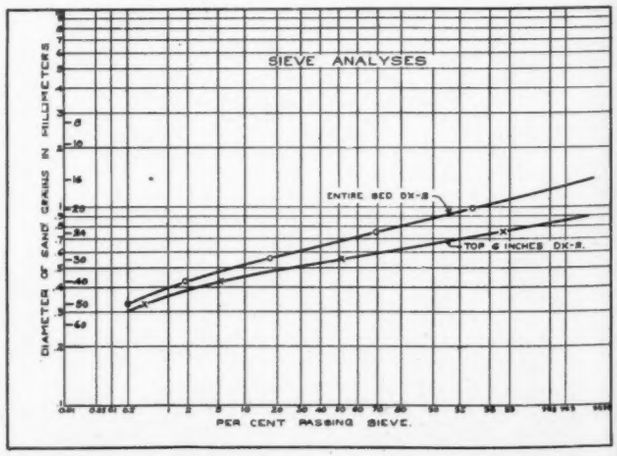


Fig. 1—Plotting Filter Sand Analysis in Table I.

*Associate Editor, WATER WORKS AND SEWERAGE.

[1]This is one of a series of three articles dealing with filtering materials. The first appeared in the April issue.—*Editor.*

tains this percentage by weight finer than the diameter to which reference is made. The 1 per cent size means that 1 per cent of the weight is finer.

Determining the Effective Size of Sand for Rapid Sand Filters.—The 1 per cent size of the sand shown in Table 1 is 0.400 mm. diameter. Multiply this figure by 1.5 ($1.5 \times .400 = .600$), and find the percentage of sand finer than this size, which in this case is 28 per cent. Add the sizes of sand determined from the graph which are less than 1.5 times the 1 per cent size, except that no size greater than the 32 per cent size is to be used in computing the effective diameter. This usually will include the 1, 2, 4, 8, 16, and sometimes the 32 per cent sizes for most filter sands. If less than 32 per cent of the sand has a diameter less than 1.5 times the 1.0 per cent size, determine the size by taking the proportional difference between the sizes on each side of the point. For the sand shown in Table 1 1.5 times the 1 per cent size gives a size in which 28 per cent of the material by weight is finer. Take the average of the sum of the 1, 2, 4, 8 and 16 per cent sizes, and the average of the 1, 2, 4, 8, 16 and 32 per cent sizes. Subtract the average sizes, which in this case is 0.025. The difference between 16 and 28 is 12, and the difference between 16 and 32 is 16. The figure obtained by subtracting the two averages of the diameters is multiplied by 12/16, which gives 0.019, and this value added to the lower average diameter, which for the sand shown in Table 1 is the average of the 1, 2, 4, 8 and 16 per cent sizes. The figure obtained (0.489 mm.) is called the *effective size of the sand for rapid sand filters.* This is intended to apply to sand used in filters that are washed by reversing the flow of water through the bed to partially suspend the sand during the washing process. It should be explained that this is based upon a filter bed 24 inches in depth of sand. It will be noted that the 64 per cent size is not taken into consideration. This size is determined, however, because it probably will be used in specifications for filtering materials.

Discussion.—The reason for using the sum of the sizes less than 1.5 times the 1 per cent size is the following: The weight of a sphere 1.5 times larger in diameter than that of another sphere, of material of the same specific gravity, is approximately 3.4 times the weight of the smaller sphere. It will be found that in washing a filter there will be very little material of the smallest size mixed with material 1.5 times larger in diameter; that is, stratification is nearly complete when there is this much difference in the diameter of the particles. Especially is this the case when the material is somewhat rounded. It must be admitted that the 1.5 factor may not be the most exact figure, but in the absence of more specific data it is believed that this ratio is a practical one.

It is easy to see that as the sand becomes less uniform in size, more and more stress should be placed upon the finer sizes. For some materials it may mean that only the 1 and 2 per cent sizes are used to determine the effective size, whereas for very uniform sands all of the sizes may be less than 1.5 times the 1 per cent size. Where the sand is very uniform in size there will be only partial stratification of the material according to size near the top of the filter bed. The percentage of the material which is finer than 1.5 times the 1 per cent size is called the *uniformity coefficient.*

It will be noted that none of the sand in excess of the 32 per cent sizes is taken into consideration in determining the effective size of a sample representative of the entire bed. This may not be the largest size which should be used for very uniform sands where the 1.5 ratio crosses the line at a size greater than the 32 per cent size, yet it gives results which are close to those obtained on less uniform sands which are commonly employed in filtration practice. More exact data on very uniform sands may show that some size beyond the 32 per cent size also should be taken into consideration.

Determining the Effective Size for Beds Shallower or Deeper Than 24 in.—Since there is always a partial stratification of the filtering material as the result of washing the bed with an upward flow of water, it is evident that the depth of the bed influences the effective size. If the bed is to be but 18 inches in depth, sieve the sample and determine the percentages of the material which will pass the various sieves. Multiply these percentages by 18 and divide by 24; that is, multiply the percentages of material passing the sieves by the depth of the bed in inches and divide by 24. This applies to beds deeper than 24 inches as well as shallower beds. Deeper beds will then have percentages greater than 100 for the coarser sieves, but the higher percentages likely will not enter into the determination of the effective size, especially if the upper limit is set at the 32 per cent size. If the sample is collected from the top 6 inches of a bed already in service, the depth is ignored in determining the sand size, as the effective size is determined by the procedure which will be given for the top material. It is believed that the material in the top few inches of any filter bed is the material which largely determines the rate at which the loss of head will increase when the filter is in service, regardless of the total depth of the bed.

If sand the same as that shown in Table 1 is used in a filter bed less than 24 inches in depth, the real effective size is greater than 0.489 mm. because there will not be so much fine material to wash to the top. Assume an extreme case in which the bed is only 6 inches in depth. The effective size determined according to the new procedure will be approximately 0.57 mm. instead of 0.489 mm. for a 24-inch bed. If the bed is deeper than 24 inches the effective size will be less than 0.489 mm., depending on the depth, because a larger amount of finer material is washed to the surface. The Hazen method for determining the effective size (which was never intended for rapid sand filters) does not take the depth of the bed into consideration, yet any method to be accurate must do so. It should be said in fairness to the Hazen method that the depth could be taken into consideration the same as is done with the new method, and if there are those who are unwilling to give up the Hazen method, they should at least make this change in the procedure for determining the effective size of the sand.

Determining the Effective Size of Sand in Filters in Service. It is important to have some method of determining the effective size of sand which is in use in a filter bed. Various methods have been suggested for determining this size. Some have attempted to get a representative sample from the entire depth of the bed, while others have sampled the sand at the surface by taking a sample at some definite depth below the surface, or by taking it from the surface to some definite depth below the surface. The writer is of the opinion that the latter is the best procedure, though it is important to know something of the size of all of the material in the bed. It is the sand at the top of the bed which determines the rate at which the filter will clog, but the lower material may serve a useful function in preventing coagulated material from passing through the filter. This of course is assuming that the amount and character of suspended material in the water remains the same, for this greatly influences the rate at which the filter clogs.

Considerable study has been given to the depth to which sand samples should be collected. It is believed that the depth should be from the surface to 6 inches

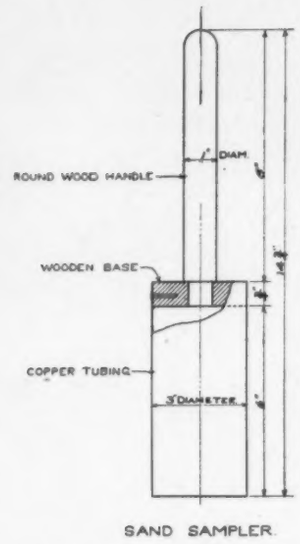


Fig. 2—Sampler for Collecting Top 6 in. of Sand in Filters.

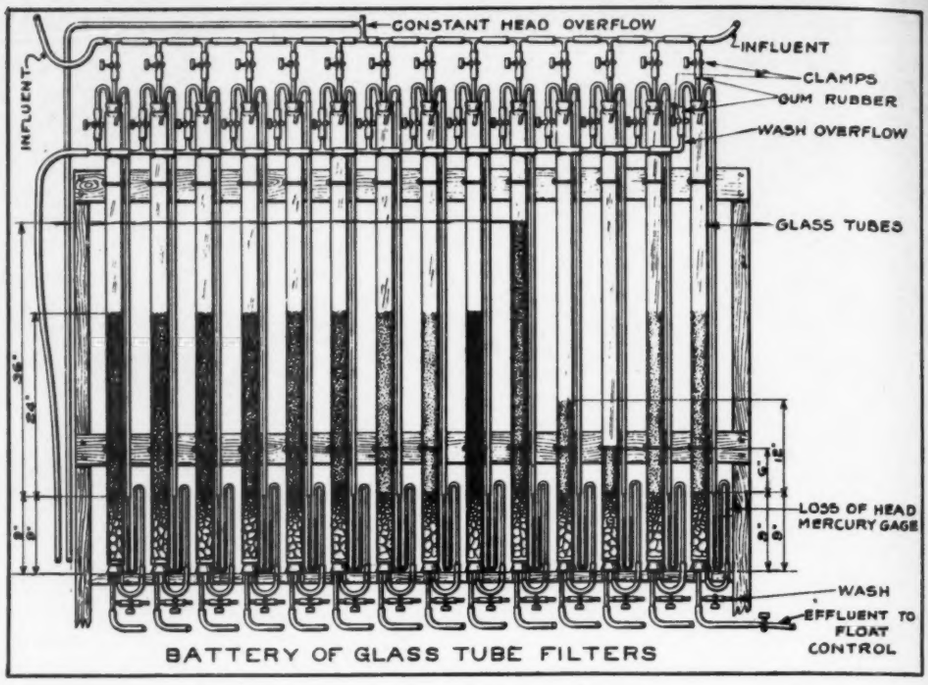


Fig. 3—Battery of Glass Tube Filters.

below, though the top 4 inches may give fairly good results. A sampling device illustrated in Figure 2 is convenient for collecting the samples. Drain the water from the filter and select several points at different locations on the filter surface to collect the sample. The sample collector should be just 6 inches in length inside. Push this down 6 inches into the sand, then dig the sand from around the collector on one side to the bottom of the sampler and push a plate or cover of some kind through the sand so that the sampler full of sand may be lifted without loss of any of the sand. This may not be necessary if the sand remains in the collector by tilting the tube after it has been forced to the right depth. For beds of one million gallon capacity or greater, it is believed that samples should be taken from at least 4 parts of the bed. Mix these samples thoroughly and take a portion for sieving. The mud should be washed from the sand, though if the sand grains are encrusted with some fairly hard material the washing should not be violent enough to knock off this encrustation if it is possible to avoid doing so. Dry the sand at a temperature of about 100 deg. C. Weigh out 100 grams and sieve in accordance with the method already given.

After the percentages of the material which passes the various sieves have been determined, plot the points on some form of cross section paper, as previously described, and determine the 1, 2, 4, 8, 16, 30, 60 and 90 per cent sizes. Take the diameter of the 4 per cent size and multiply it by 1.5. Add the various sizes, beginning with the 2 per cent size, up to and including the 90 per cent size, if this size is not greater than the figure obtained by multiplying the 4 per cent size by 1.5. In case 1.5 times the 4 per cent size is less than the 90 per cent size, take the average of the diameter on each side of the figure and compute the proportional difference in the manner given for the entire bed. Table 2 shows sieve analysis of the top 6 inches of the sand which is covered in Table I. The percentage of the material finer than 1.5 times the 4 per cent size is called the uniformity coefficient.

Assume that 1.5 times the 4 per cent size is between the 60 and 90 per cent sizes, determine where this point crosses the line which has been plotted. It crosses at the 84 per cent size for the sand shown in Table 2. Determine the average diameter of the sizes from 2 to 60 per cent, and the average diameter of the sizes from 2 to 90 per cent. Take the difference between the two sizes and add to the 2 to 60 per cent size the proportion of the distance between 60 and 90. The difference between 60 and 90 is 30. Subtract 60 from 84, which will leave 24. Then take 24/30 of the difference between the average diameters from the 2 per cent size up to the 60 per cent size, and the average up to the 90 per cent size, which is 21. This figure when added to the average of the diameters from 2 to 60 per cent, gives 0.489 mm. diameter for the effective size. In the particular analyses shown the effective size of the sand as deter-

TABLE II—SIEVE ANALYSIS OF TOP 6 INCHES OF MUSCATINE SAND FROM FILTER D X-2
(March 1, 1934)

Total of 3 Sieved Portions

Sieve	Grams Retained on Sieve	Total Grams Passing Sieve	Per Cent Passing Sieve
16	0.0	313.3	100.0
20	0.0	313.3	100.0
24	4.2	309.1	98.7
30	152.1	157.0	50.2
40	140.8	16.2	5.2
50	15.0	1.2	.4
60	1.0	.2	.06
80	.1	.1	.03
Less than.... 80	.1		

2 Per Cent Size	.385 mm. dia.
4 Per Cent Size	.420 mm. dia.
8 Per Cent Size	.445 mm. dia.
16 Per Cent Size	.475 mm. dia.
30 Per Cent Size	.510 mm. dia.
60 Per Cent Size	.570 mm. dia.
90 Per Cent Size	.655 mm. dia.

Average of 2 to 60 per cent diameters	.468 mm.
Average of 2 to 90 per cent diameters	.494 mm.
Per cent of material of diameter less than 1.5 times the 4 per cent size	84
Diameter of the effective size of the sand	.489 mm.

mined from sieving before the material was placed in the filter and the effective size determined by taking a sample from the top 6 inches of the bed after it had been in service for a short time were the same. This of course was an accident, but the two sizes should be very close. It has been found from a number of such tests on various sands that the results are close.

In the analyses shown, 24 inches of sand were used in the filter. The sample collected from the top 6 inches of the bed represented 25 per cent of the total depth. If there was complete stratification of the sand according to size, the 1 per cent diameter of the original sand before being placed in the filter should correspond to the 4 per cent diameter of the top 6 inches. The stratification according to size is not complete, and to get a figure for the effective size which is approximately the same as that obtained on the original material, it is necessary to use the 2 per cent size in addition to the 4, 8, 16, etc., sizes. When the uniformity coefficient is 95 or more, the 1 per cent size also should be used. The analyses in table 3 show samples collected from the surface of the bed to 2 inches below, from 2 to 4 inches below and from 4 to 6 inches below. It is evident from these analyses that there is not complete stratification of the sand according to size.

The various per cent sizes selected for determining the effective size of a sample collected from the top 6 inches were chosen because the average gave results very close to that obtained by sieving a sample representing the entire bed. If it should be found that some other combination is more exact, it should be used.

Experimental Results

If the new method of determining the effective size of filtering materials for rapid sand filter beds meets our needs, it must give results which will enable one to draw a correlation between effective size, uniformity and performance. The most important function of any filtering material is to remove the suspended matter from the water, and the next most important function is the lengths of filter runs which may be procured between washings. The limit of the size of sand grains which may be used for rapid sand filters, to satisfactorily filter the water, is not being discussed in the present article, and it is assumed that the conditions which govern the removal of coagulated matter from water are fairly well known. However, we are very much concerned with methods of specifying materials which will bring about this removal most efficiently. Sand occurs in many localities throughout the country, much of this sand is not of the proper size for filters, or at least only a portion of the material is of the proper size. The character of the water has great influence on the lengths of filter runs, but it is possible to modify this influence to a certain extent by proper selection of the filtering material. This makes it essential to determine the true effective size of filtering materials with considerable exactness.

Method of Conducting Tests.—Glass tube units, as shown in Figures 3 and 4, were used. The water was coagulated and settled in the Experimental Plant. Since it was obtained from the same point for all of the filters, any difference in the results of the filters should be attributed to the filter and not to a variation in the water going to the units. Three groups of filters were used. One group was known as the Armstrong Series of filters. The second group was known as the Uniform Sands, and the others were ordinary filtering materials graded in about the manner in which they occurred naturally. This does not take into consideration tests on various other materials which will be discussed in another article.

The Armstrong Series of filters were filled with sand sieved by Mr. Jas. W. Armstrong of Baltimore. A large

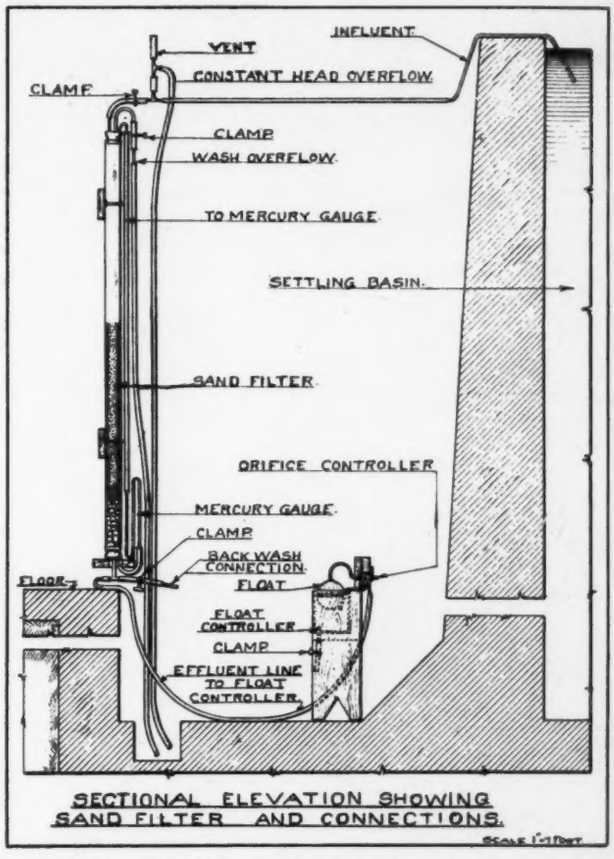


Fig. 4—Glass Tube Sand Filter—One of a Battery.

amount of this material was sieved and portions sent to a number of filtration plants throughout the country. When placed in filters according to the instructions of the sender, it formed filters in which the beds varied widely in size and grading of the sand. The Uniform Sand filters represented material retained on a certain sieve after passing the sieve with openings next larger in size. The material was sieved by hand and no attempt was made to sieve the material as thoroughly as is usually done in sieve analyses. It was sieved well enough, however, to give fairly uniform grading of the material. The sand used was Muscatine sand, except for the coarser and the finer sizes which were not available in the Muscatine sand.

The materials used in the tests were ordinary silica sand and the grains were fairly rounded, though some of it probably would be classified as sub-angular material. Tests have been made on angular materials, but shape of materials will not be discussed in this article. It is believed that the shape was near enough alike in the tests

TABLE III—SIEVING OF TOP SAND IN FILTER DX-2
(March 2, 1934)

		Per Cent of Material Passing Sieve		
	Sieve Number	Top 2 Inches	2 Inches to 4 Inches	4 Inches to 6 Inches
	20	100.0	100.0	100.0
	24	99.2	99.3	97.4
	30	80.7	52.1	28.8
	40	15.6	2.3	1.1
	50	1.0	.3	.1
	60	.1	.1	.0
Less than....	60	.1	.0	.0

now being discussed for this to have practically no influence on the results.

Most of the tests were conducted at a filtration rate of 2 gallons per square foot per minute, though the rate was varied for one series of tests. The length of filter run was the time required for the filter to reach 8 feet loss of head. The loss of head gauges were connected in such a manner that the loss shown was that through the bed and not through both the sand bed and the filter underdrains, as is usual for measuring the loss of head through filters. Twenty-two filters were in use part of the time.

Tests Included Wide Variation in the Size and in the Grading of the Sands.—Table IV, which shows the sievings of most of the sands used, shows that there was wide variation in the size of the sand as well as the uniformity of the material in the beds. The table gives both the effective size determined from a representative sample of the bed and the effective size determined from the top 6 inches of the beds after the sand had been stratified by washing. Also the 10 per cent sizes are shown. The sizes determined by the two methods (according to the new procedure) are close enough for practical purposes. It is difficult to properly plot the sieving of a sand very uniform in size, especially when most of the material ranges in size between two sieve openings. Some deviations in the results are expected for very uniform materials. The table shows, however, that the deviations are not great enough to materially affect the results. It is believed that the wide variations in the filter beds, both in uniformity and in size, furnishes an excellent opportunity for testing the proposed method of determining the effective size of the bed. If the method is satisfactory, it should make no difference how irregular the grading of the material may be, for it will put it into its proper classification according to size. Data will be given to show that this is the case. It should be evident that the use of some certain size of the sand, such as the 10 per cent size, will not hold for beds varying widely in grading.

These tests were started in July, 1929, and have been under way almost continuously since then. The Uniform Sand series were started in August, 1930. Results of 3 to 4 years' work are available. Very little of the data will be given, as it is assumed that the reader is more interested in a summation of what the experiments show than in a mass of figures.

Relation of Sand Size and Length of Filter Run.—The results of one series of experiments run for a period of approximately one year (March, 1932, to March, 1933) are plotted in Figure 5. This includes the Armstrong Series of filters, the Uniform Sand filters and two filters of ordinary sand grading. The effective size of the material varied from .235 mm. to 1.78 mm. diameter. These filters cover a wide range in size and include materials finer, as well as materials coarser than are ordinarily used in filtration plants. It will be noted that the points are approximately in a straight-line when plotted on logarithmic paper. The slope of the line is 2.15, which means that the length of the filter run varies as the diameter of the sand to the 2.15 power. It is evident that this relation will not hold for very fine material, nor for very coarse material. A point in fineness can be reach in which the initial loss of head on the filter will be 8 feet, the maximum total loss considered in the experiments. Also there probably is a size in which the loss of head will not increase to any material extent, due to the coagulated material being carried on through the coarse material.

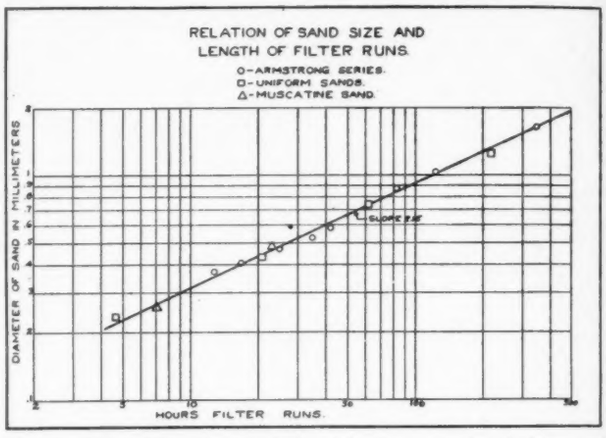


Fig. 5—Curve Showing Relationship Between Sand Size and Length of Filter Runs.

The equation for computing the effect of the size of sand upon the length of filter run is

$$H = K D^{2.15}$$

H = length of filter run in hours.

K = a constant which varies with the clogging tendency of the water.

D = diameter of the effective size of the sand.

The value of K is something which can be determined only by actual tests. Filtration plant operators may work out the limits of K for their conditions and be able to use the equation to determine if changes in the size of their filtering material will result in improved conditions, but K cannot be determined by computation. The equation is good for fairly clean materials where the filter beds do not pull away from the side walls of the filters and do not form surface cracks. Cracks in the surface of the filter bed and along the side walls increase the filter runs over what they would be if there were no cracks.

TABLE IV.—EFFECTIVE SAND SIZE AND UNIFORMITY COEFFICIENT OF FILTER BEDS

Column 1. Uniformity Coefficient. Per cent with size less than 1.5 times the 1 per cent size.

Column 2. Effective size determined before being placed in filter (mm. dia.).

Column 3. Uniformity Coefficient top 6 inches. Per cent with size less than 1.5 times the 4 per cent size.

Column 4. Effective size determined from top 6 inches of filter (mm. dia.).

Filter	(1)	(2)	(3)	(4)	10% Size (Hazen Method)
Muscatine, Ia. (DX-2)...	28	.489	84	.489	.513
Ottawa, Ill. (JX-3).....	54	.503	98	.494	.520
Copley, Ohio, Crushed Quartz (EX-3)	28	.475	70	.471	.499
Muscatine, Ia. (DX-1)...	7.5	.257	32	.255	.336
Armstrong Series—					
No. FX-2 (1)	27	.370	90	.366	.383
No. GX-2 (2)	29	.403	93	.395	.418
No. HX-2 (3)	34	.474	82	.485	.490
No. D-5 (4)	37	.527	82	.540	.539
No. Z-3 (5)	18	.582	83	.603	.644
No. ZX-2 (6)	32	.877	70	.876	.870
No. LX-1 (7)	16	1.031	60	1.035	1.15
No. MX-1 (8)	11.5	1.620	42	1.580	1.93
Uniform Sand M-2	23	1.780	27	1.674	1.94
Uniform Sand N-2	95	1.265	95	1.256	1.325
Uniform Sand Y-1	85	.854	96	.899	.870
Uniform Sand P-2	89	.738	99	.725	.773
Uniform Sand Q-2	95	.543	100	.556	.555
Uniform Sand R-2	99	.434	100	.436	.444
Uniform Sand S-2	38	.279	97	.295	.290
Uniform Sand T-2	94	.235	95	.245	.243
Non-Uniform D-6	2.4	.263	8	.272	.495
Average.....	..	.666	..	.664	.716

If the points in Figure 5 are examined more closely, there is some indication of it being curved instead of straight. Whether this is due to experimental errors or to a true relation, it is not possible to state at the present time. It is believed for practical uses that the points are near enough on a straight line to use the straight line relation. It should be stated that this information was obtained upon water with a fairly high clogging tendency, and that the effect of the size of the material on some other water may be slightly different from the 2.15 power of the diameter. It is believed that the figure will range between the square of the diameter and the 2.5 power of the diameter for different waters. The 2.5 power will probably be close to the correct figure for waters with a low clogging rate, and the 2.0 power close to the correct figure for waters with a high clogging rate. This statement, however, cannot be confirmed until data are available on waters of different character.

The materials in the uniform sands were very uniform, and the grading in the Armstrong Series was not as uniform as that in most of the sands ordinarily used in filtration. If close results are obtained by using ordinary sands, uniform sands, and sands which were not so uniform, it indicates that the new method of determining sand size gives the true size effect. To test the method more thoroughly, one of the natural sands (which was a fairly uniform sand for a natural sand) had two per cent of fine sand added to it. This produced a very non-uniform grading. Comparison of the runs on this filter with those on a filter containing the uniform sand showed approximately the same relation between the diameter and lengths of runs as that for the other sands. Therefore the new method of determining the size apparently holds for any grading of the material whether very uniform or very non-uniform. It, of course, should do this if it is a method which determines the true effective size of sand for rapid sand filters.

When materials are compared on the basis of the size of some definite percentage of the weight of the material, fairly good relations may be obtained for a series of sands which do not vary widely in the uniformity of the material. This explains why we have been able to obtain fairly satisfactory results by use of the 10 per cent size when a limit is placed on the non-uniformity of the material by specifying that the uniformity coefficient according to the Hazen method be not greater than 1.5. It, however, is known that this method does not hold for very non-uniform materials, and not being accurate for all conditions it is not the most exact method which may be used. Frequently water works have spent considerable sums of money to obtain sand which is known to have worked satisfactorily in other plants, when they may have had satisfactory material near at hand but were unwilling to take a risk on the material when they had no positive means of determining its qualities in advance of actually trying the material in filter beds. It is believed that the new method of analyzing sands will overcome this difficulty and will enable water filtration plants to obtain the cheapest material suitable for their needs.

The present discussion is limited to natural sands, but the method of determining the effective size holds for crushed or angular materials. In this case the porosity is different from that of natural sands and to compare such materials with natural sands, the porosity and perhaps the shape of the material also has to be taken into consideration. Since more than 90 per cent of the filtration plants use natural sand, it is believed best to use as simple a relation as is possible for classifying these materials, and when other types of materials are used, such as crushed quartz or crushed anthracite coal, the other factors affecting the results can be taken into consideration. Such materials will be discussed in a later article.

It might be more exact to compare the materials on the basis of the rate of increase in the loss of head. In this event it will be necessary to take into account the initial loss of head, so as to subtract from the total loss. This might then bring into use an equation for the flow of water through sand for determining the initial loss. So far as the writer can see at the present time, this is about the only use we will find for the equations (given in the first article of the series) which have been developed for computing the initial loss of head through filter beds. Usually we are concerned only with the lengths of runs which are obtained on the filters for a given available total loss of head which is constant for most plants. That is, the plant is designed so that a definite total loss of head may be obtained and if it is not necessary to bring into account the initial loss of head, it seems that the information desired can be obtained with a swing of considerable computation.

The method of determining the effective size of sand for rapid sand filters is not one of computing the length of filter runs which will be obtained for some given size of sand, consequently the filter run for one size of the material must be known. At present we have no means of even approximating the length of filter run which will be obtained on a certain water for a given sand, but once the run is determined for one size of sand the effect of varying the sand can then be determined. Due to wide variation in the clogging tendency of coagulated material, there is not much possibility of being able to compute filter runs for some given set of conditions without knowing the runs for some other condition.

Most of the Filtration Occurs Within the Top Few Inches of the Filter.—It is well known that most of the filtration in a rapid sand filter bed takes place in the top few inches of the bed. The depth to which the coagulated material will penetrate depends upon several conditions, the most important of which are the size of the sand and the character of the coagulated matter. When the sand is fairly fine, most of the filtration may take place at the surface of the bed, but when it is fairly coarse it may penetrate to considerable depth and occasionally some of the coagulated material passes through the filter bed before the loss of head reaches the maximum. It would seem that the effective size for filtration for very fine sand is that size which is found in the top 1 or 2 inches of the beds, and for fairly coarse sand that from the top to 6 to 12 inches below. For the average rapid sand filter where the length of the run is not greater than 48 hours, it is believed we can assume that the lengths of the runs are dependent upon what takes place within the top 6 inches of the filter bed.

It is known that there are times when the clogging rate is high in which only a part of this top 6 inches of sand does any filtering, because most of the coagulated material is removed in the top one or two inches of the bed.

To determine the effect of depth, a sample of sand large enough to fill two glass tube filters 24 inches in depth was mixed very thoroughly. Filters Q-3 and R-3 were filled 24 inches with this material and washed. Six inches of the surface sand, after thorough washing, was removed from filter R-3. Then the balance of the sand was removed and the top 6 inches returned to the filter. This gave a bed 6 inches in depth in which the effective size was the same as that of the other filter, which was 24 inches in depth. Figure 6 shows the plotting of typical runs on these filters. The deeper bed of sand naturally had a higher initial loss of head. The top of the bed also was at a level 1½ feet higher than the top of the other filter. It will be noted that the loss of head increased at almost exactly the same rate until the loss on the deeper bed reached 7 feet. Then it increased on

this filter a little more rapidly than on the shallower bed. This was due to air binding of the filter, which started at approximately 7 feet loss of head. The shallow filter being on a lower level did not become air bound.

During periods when the runs on these filters were in excess of about 35 to 40 hours, a small amount of flocculated matter passed through the shallow filter. This kept increasing as the filter was continued in service. The passage of a small amount of flocculated matter did not appear to materially affect the clogging rate. The data indicate that the real effective size of a filter bed can be determined by sieving a sample of the top 6 inches of sand in the bed. The advantage of this is that it is not necessary to try to collect a sample of material representative of the entire depth of the bed. The passage of any coagulated matter is objectionable and shallow depth filters will not give satisfactory results unless the lengths of the runs are less than about 35 hours, and the turbidity of the coagulated matter going to the filter is not above 5 parts or thereabouts.

It is not the purpose of this article to discuss penetration of the coagulated matter into filter beds, though it is

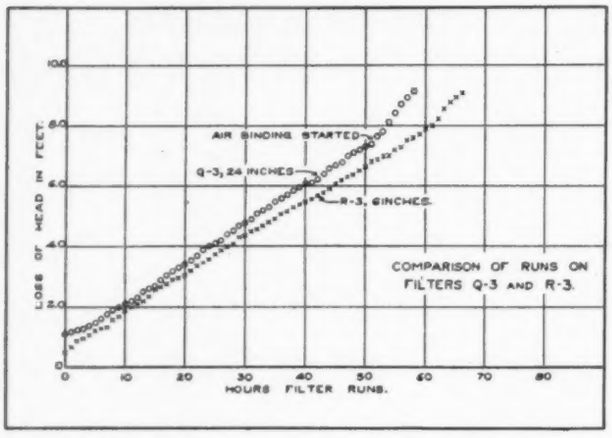


Fig. 6—Typical Curve of Length of Runs of Filter Beds 6 in. and 24 in. in Depth. Shallow Filter Contains Top Sand Only.

a factor which must be taken into consideration in determining the size of the filtering material to use. It should be evident that the coarser beds of sand used in these experiments passed coagulated matter before the loss of head reached the maximum. In fact the two coarsest filters frequently passed some coagulated matter at the beginning of operation, and by the time the loss of head reached 8 feet, most of the coagulated material going on to the bed passed on through. It is interesting, however, to note that the runs on these filters gave points almost exactly in line with the runs on filters containing finer material. It is doubtful if practically all of the head loss occurred in the top 6 inches of these coarse sand filters, though it may be that it was so very much greater than that which occurred in the lower part of the beds that the lower part did not materially affect the results.

Summary

A new method of determining the effective size of sand for use in rapid sand filters is described. The new method is based upon the average of the 1, 2, 4, 8, 16 and 32 per cent sizes, except that maximum size used in the average is 1.5 times the 1 per cent size.

The uniformity coefficient is the percentage of the material having a diameter less than 1.5 times the 1 per cent size.

The method is applicable for determining the effective size of sand from filter beds already in service. A sample taken to represent the top 6 inches of a filter bed may be used for determining the effective size.

The method of conducting the experiments is explained. Twenty-two glass tube filters were used. The tests include wide variations in the size and grading of the materials.

The average lengths of the runs varied with the 2.15 power of the diameter of the effective size. This is not an exact figure for all waters, and it is believed to vary from 2.0 to 2.5. It probably will be near the lower figure for waters with a high clogging rate, and near the larger figure for waters with a low clogging rate.

Regardless of the uniformity or non-uniformity of the material in a filter bed, the new method gives the true effective size, in so far as it applies to the lengths of filter runs.

▼

Association Meetings Scheduled

June 4-8—Annual Convention of American Water Works Association. Hotel Commodore, New York City. Secretary, B. C. Little, 29 W. 39th St., New York City.

June 5-6—**Arizona Public Health Association.** Prescott, Ariz. Secretary, Jane H. Rider, Director State Laboratories, Tucson, Ariz.

June 13-14—**Illinois Association Sanitary Districts,** Waukegan, Ill. Secretary-Treasurer, G. H. Radebaugh, Urbana, Ill.

June 15-16—**New York State Sewage Works Association.** Jamestown, N. Y. Secretary, A. S. Bedell, State Department of Health, Albany, N. Y.

June 25-27—**Pennsylvania Water Works Operators' Association.** State College, Pa. I. M. Glace, Secretary, State Department of Health, Harrisburg, Pa.

June 28-29—**Pennsylvania Sewage Works Association.** State College, Pa. L. D. Matter, Secretary, State Department of Health, Wilkes-Barre, Pa.

July 12-14—**Virginia Section, A. W. W. A.** Martinsville, Va. Secretary, H. W. Snidow. State Department of Health, 601 State Office Building, Richmond, Va.

Aug. 22—**West Virginia Conference on Water Purification.** Hotel Windsor, Wheeling, W. Va. Secretary, J. B. Harrington, State Department of Health, Charleston, W. Va.

Aug. 23-24—**Central States Section, A. W. W. A.** Hotel Windsor, Wheeling, W. Va. Secretary, H. L. Nelson, U. S. Pipe and Foundry Co., 2435 Koppers Bldg., Pittsburgh, Pa.

Sept. 3-6—**Annual Meeting of American Public Health Association.** Pasadena, Calif. Willimina R. Walsh, Secretary, 450 7th Ave., New York City.

Sept. 17-19—**Rocky Mountain Section, A. W. W. A.** Santa Fe, N. M. Secretary, B. V. Howe, Board of Health, Denver, Colo.

Oct.—**California Section, A. W. W. A.** Long Beach, Calif. Secretary, J. E. Phillips, Department Water Supply, 207 Broadway, Los Angeles, Calif. (Exact date later.)

Oct. 15-18—**Southwest Water Works Association.** Hotel Hilton, Waco, Texas. Secretary, Lewis A. Quizley, Superintendent Water Department, Fort Worth, Texas.

Nov.—**North Carolina Section, A. W. W. A.** Virginia Dare Hotel, Elizabeth City, N. C. Secretary, H. G. Baity, Dean of Engineering, University of North Carolina, Chapel Hill, N. C.

Nov. 8-10—**Missouri Valley Section, A. W. W. A.** Hotel Fontenelle, Omaha, Neb. Secretary, Prof. E. L. Waterman, University of Iowa, Iowa City, Ia.

▼

NEW YORK'S $130,000,000 SEWAGE PROJECT ADVANCED.—The governor of New York on May 8 signed the bills empowering the city of New York to issue coporate stock to pledge with the Federal Government for grants and loans for the proposed $130,000,000 sewage disposal system.

EDITORIALS

On Attending Conventions

THE coming annual Convention of the American Water Works Association to be held in New York City, June 4th to 8th, brings to mind the question of the value of technical and professional associations; the advantages gained through the meeting of members and guests during conventions held by such organizations.

Until one becomes acquainted with the ramifications of work undertaken by the numerous technical committees of such associations, he fails to appreciate one of their highest values to the fields they serve. Working all year on matters of assignment these committees render reports at annual meetings which are there discussed. To those present at the presentation the findings and conclusions of such committees become appreciably more intelligible than does the same report when it later appears in cold type. The same reasoning applies in connection with papers read; for, it is frequently the side remarks of the author, the questions from the floor, the free discussion which follows that clarifies many points brought forward; and, adds interest which is so frequently lacking in the published article when it appears in print. To the operating man and the manager the "Round Table Discussions" are invaluable—particularly so if he enters into these "experience meetings" with a spirit of give and take. One can not possibly gain the value of such intimate discussion nor can he read between the lines of such discussion by staying away from conventions and depending on printed reports—if there be such—to enlighten him.

This is all intended as an answer to the argumentive question of many who say: "Why should I attend meetings to listen to papers and discussion which I can read later?" Some technical papers can be read, perhaps better than slept through, but to attain progress through such procedure is slow—often painful. It is the live topic which brings on the sort of discussion which makes for progress by stimulaion of listeners. It is this that one can ill afford to miss by staying out of meetings on the grounds that he has been put to sleep by the reading of certain papers which he has had to sit through at some previous meeting.

To many who attend meetings and conventions of technical associations, the greatest value comes from informal group discussions—sometimes arguments—which occur on the "side-lines," in the rooms—even at the breakfast table. Many operators have problems which he believes some other member can assist him with and if he makes inquiry openly or privately he can usually find the help he needs. For this purpose there is nothing superior to the open "Question Box" which receives written questions to be read and answered openly in meetings, with or without disclosing the identity of the questioner. Through this procedure, the operator who seeks assistance may benefit even more by making his identity known.

The American Water Works Association in recent years has made a feature of its exhibit of equipment and materials used in the water supply field. Realizing the educational value of exhibits effectively displayed the Water Works Manufacturers Association has stimulated this phase of exposition in its annual award of three prizes to manufacturers staging the most effective and instructive exhibit at Annual Conventions of the Association. There is much to be gained of educational and economic value by visiting equipment exhibits. New developments and improvements become readily understood when displayed in the form of working models or as actual equipment, with experts and factory representatives on hand to explain their functions and values; to answer questions at first hand—something which advertisements, literature and catalogs frequently can not effectively do. Within an hour or two the visitor can learn more in the exposition of equipment and materials than he might ever glean from all the printed matter, descriptive of new developments, which reaches his desk during the year. New men find it easy to learn much about existing equipment in a plant which they have recently assumed charge of.

If the Chinese proverb which says that "One picture is worth 10,000 words" be correct, then, one exhibit is worth several pictures and as many thousand words. In its best sense advertising is educational. Effective exposition of materials and equipment is possibly the highest form of advertising and makes for advancement; for, if every operator were left to discover for himself what he lacks, progress would be mighty slow.

Stimulation is a great help in any phase of human endeavor and perhaps the highest value of water works or sewerage conventions is that of stimulation of individual effort to improve the appearance and the operation of his works, to better his own position. The young man who makes scant if any effort to seek authorization from his superior to attend technical meetings and conventions is rapidly dropping into a rut from which he will find it increasingly difficult to extricate himself. Ambition to get ahead, is not sufficient; he must have the *will* to do so and the willingness to sacrifice in his early years. The excuse, that the powers-that-be will not allow travel expense, is poor reason for staying at home. Realization that his loss is his employer's loss may alleviate his feelings of regret, but it will not get him the opportunity to better his standing—perhaps, to find a more appreciative employer. Experience teaches that starting to attend technical conventions on one's own resources constitutes a sacrifice which yields a high return.

Attending a Water Works Convention broadens the individual's outlook; reminds the young man that there are more than 10,000 public water works in America; reveals that his problems may be different, but not worse, than those of his contemporaries in the same field; stimulates him to a degree that he returns to his job full of energy with his chin up and ready to prove that he can put to practice some of the things he has learned of; prove too that he need not remain in a rut, that he can pay his own way anytime. The employer will find it worth while next year to pay the expense of his attending the convention.

If you feel that you are in a rut, why stay there? Borrow the money if necessary; attend the A. W. W. A. Convention and learn that ruts are only as deep as one thinks they are. If you are not in a rut you will attend the convention to keep from getting that way.

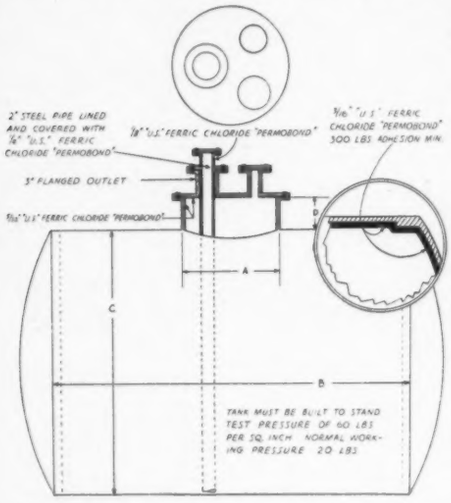
Fellowship; Education; Stimulation; Progress; Advancement—these are the keynotes of water works and sewerage conventions. "Can you afford to attend?"—the answer may be "no." But ponder this: "Can you afford *not* to attend?"—the answer is still "NO." Try the investment.

NEW EQUIPMENT AND MATERIALS

Rubber-Lined Equipment for Ferric Chloride

Ferric salts are becoming more widely used as coagulating chemicals in water purification and sewage treatment. In sewage treatment ferric-chloride is taking an important place as evidenced by the demand for storage tanks, equipment and materials to withstand its destructive action, which the commonly used materials of construction will not do.

Engineers and plant managers, confronted with the problem of choosing ferric-chloride handling equipment which is reasonable in cost, low in maintenance expense and positive in its protective qualities,


2" STEEL PIPE LINED AND COVERED WITH 1/4" "U.S." FERRIC CHLORIDE "PERMOBOND"
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C
D
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Typical Design of "U. S." Rubber Lined Chemical Tank for Ferric Chloride

will be interested in the act that rubber linings of an approved type have been thoroughly tested and found to be economical and practical in ferric-chloride handling.

Although somewhat new in the sewage field, vulcanized rubber has been used as a lining material by the chemical industry for a decade. And it has proved a satisfactory material in chlorinator manufacture for almost 15 years.

The claims for rubber lining are as follows:

(1) The initial cost is competitive; when considering the ultimate life and service. (2) Maintenance and repair expenses are practically nil; assuming that a lining of proven value is used and excessive mechanical abuses are avoided. (3) Such equipment as storage and mixing tanks, pipe, fittings and valves can be completely designed to effect maximum savings in space and efficiency.

Rubber lining can be applied with advantage to steel or wood tanks as well as to flanged metal pipe. *New* tanks are strongly recommended in that they can be properly designed for rubber lining, but used tanks can be lined provided proper preparation of the interior surface is attended to. The United States Rubber Company gives complete instructions in this regard. Further, they say, rubber linings can be installed in new (thoroughly dry) concrete tanks, but it is well to consider that possible crumbling or swelling of the cement behind the rubber lining results in sagging and probable reduction in the life of the lining. Also, used concrete tanks are seldom, if ever, in condition to justify rubber lining.

Transfer of corrosive liquids by air pressure has become standardized practice of the chemical industry. It has proven safe, efficient and positive in respect to protection. The operating pressure is customarily from 20 to 40 lbs., depending upon requirements. Rubber lined ferric-chloride equipment, as manufactured by the United States Rubber Company, is designed for service regardless of whether the installation is of the pressure-pumping or syphoning type. The cut above illustrates a representative type of pressure tank adaptable to the majority of service conditions.

The most practical type of rubber lining is one having approximate physical characteristics of a tire tread. This type offers maximum resistance to corrosion; in addition it affords outstanding protection against mechanical abuse. This lining will give and take with the expansion and contraction of steel tanks and piping, subjected to maximum changes in temperature.

Among the important installations of "U. S." rubber lined tanks and equipment, at sewage disposal plants, are those at Milwaukee, Chicago, and Indianapolis.

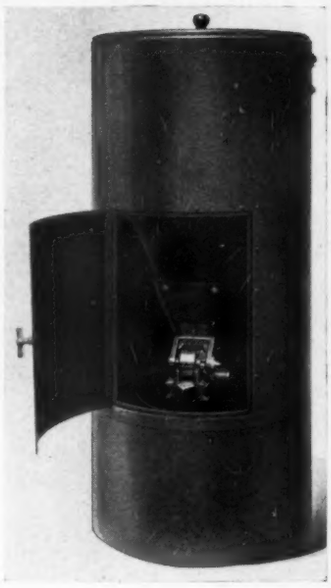
For descriptive literature, or further details concerning rubber lined tanks, pipe, fittings, pumps or chemical rubber hose, address, United States Rubber Company (Tank Division), 1790 Broadway, New York City.

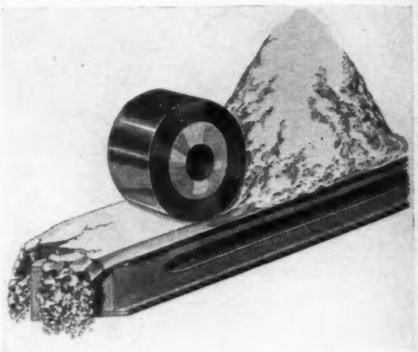
▼

W. and T.'s New "Free Wheeling" Chemical Feeder

Wallace & Tiernan, Inc., Newark, N. J., have just announced the MOF dry Chemical Feeder which employs new and interesting principles in feeding dry chemicals. In fact, the chemical does not have to be *so* dry to be fed by this new "free-wheeling" type of feeder.

Some of the features are: the oscillating feed spout which travels backward and forward to preclude clogging; self agitating, non-arching (flexing) hopper; sealed, leak-proof feed plate; improved feed adjustment, accurate and dependable; low water consumption, efficient swirl solution pot of earthenware; completely dust-proof housing (looks like a "G. E." furnace in the basement pool room); corrosion-proofed with cadmium plating and special rubber base paint; gear head (¼ H. P.) motor drive, provides speed reduction in one unit; high feed ratio (100 to 1),





The MOF-Dry Feeder and "Free Wheeling" Feed Device

without need of gear change or varying drive speeds; "free-wheeling" feed device.

The most ingenious features of this novel feeder are the hopper flexing scheme and the "free-wheeling feed roll" element which extrudes the chemical from the feed plate with insured uniformity. This unit is rotated by means of a feed-roll lever and is so constructed that the roll itself is free to turn on the shaft when the feed spout (tongue) moves back but is locked to the shaft and therefore slides with the chemical when the spout moves forward. Result: a continuous, smooth, uniform "ribbon" of chemical is extruded without being broken when the feed spout reverses. It is this feature which makes the new feeder dependable for feeding activated carbon damp lime and similar materials which hitherto has been somewhat difficult to feed with standard dry feeders. The feed roll assembly is adjustable to three positions to provide a feed variation from 1 to 100.

For descriptive literature write Wallace & Tiernan Company, Inc., Newark, New Jersey.

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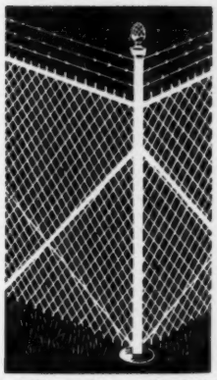

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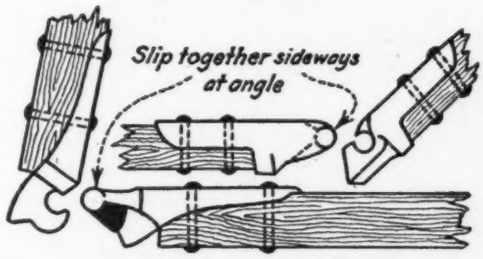

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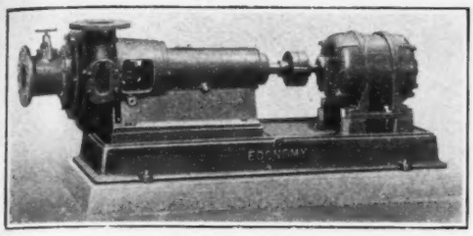

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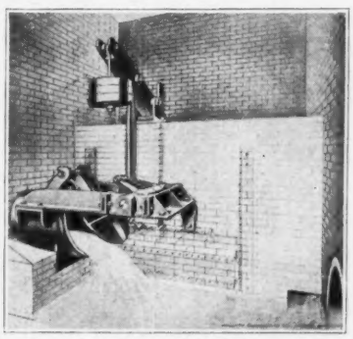

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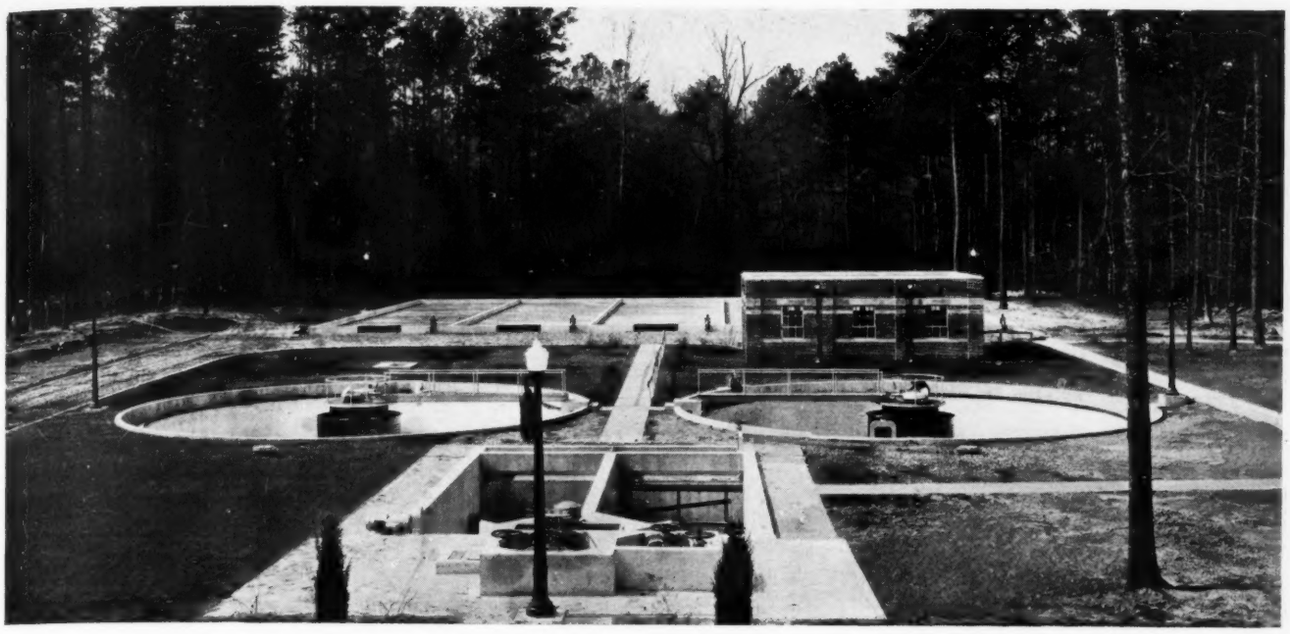

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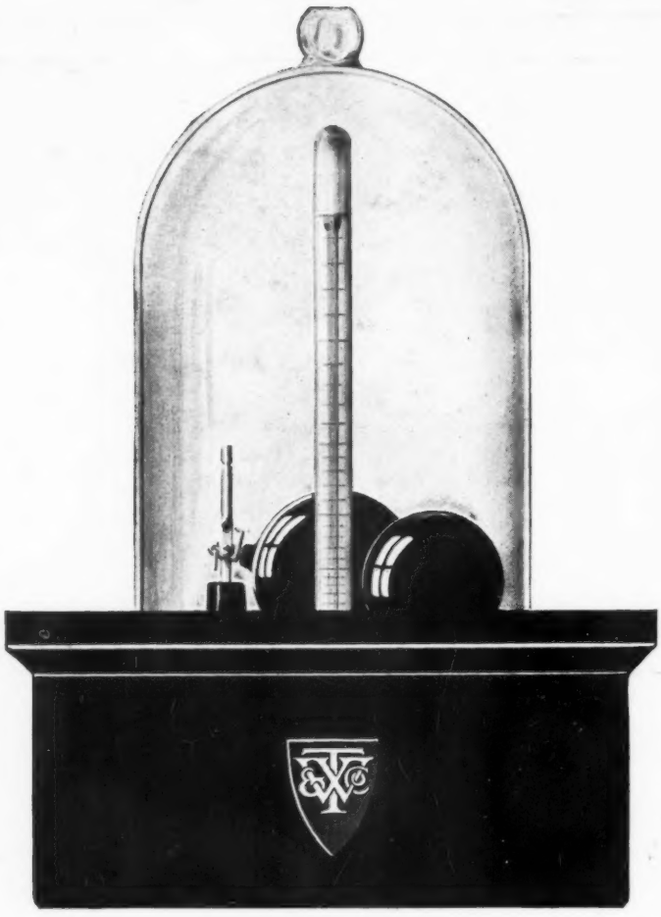

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